Vol. II

TRANSCRIPT OF RECORD

(Pages 551 to 1022a)

Supreme Court of the United States

OCTOBER TERM, 1943

No. 392

UNIVERSAL OIL PRODUCTS COMPANY,
PETITIONER,

vs.

GLOBE OIL & REFINING COMPANY

ON WRIT OF CERTIORARI TO THE UNITED STATES CIRCUIT COURT OF APPEALS FOR THE SEVENTH CIRCUIT

PETITION FOR CERTIORARI FILED SEPTEMBER 28, 1943.

CERTIORARI GRANTED NOVEMBER 15, 1943.

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Respondent.

ON WRIT OF CERTIORARI TO THE UNITED STATES CIRCUIT COURT OF APPEALS FOR THE SEVENTH CIRCUIT.

THE SUNTHORP-WARREN PRINTING COMPANY, 310 WEST JACKSON, CHICAGO

IN THE

Supreme Court of the United States

OCTOBER TERM, A. D. 1942.

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UNIVERSAL OIL PRODUCTS COMPANY,
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vs.

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In the

United States Circuit Court of Appeals

For the Seventh Circuit

No. 7912

UNIVERSAL OIL PRODUCTS COMPANY,
Plaintiff-Appellant,

vs.

GLOBE OIL & REFINING COMPANY,
Defendant-Appellee.

U. S. C. C. A.-7
FILED
JUL 31 1942
KENNETH J. CARRICK
CLERK

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THE GUNTHORP-WARREN PRINTING COMPANY, 350 WEST JACKSON, CHICAGO

DOCKETED JAN. 14, 1942.
TRANSCRIPT FILED APRIL 2, 1942.

In the

United States Circuit Court of Appeals

For the Seventh Circuit

No. 7912

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vs.

GLOBE OIL & REFINING COMPANY,
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848 DANIEL PYZEL:

Redirect Examination by Mr. Hall.

592 The furnace structure illustrated on PX 524 was of an old type and had been used in the petroleum industry at the time this unit was designed.

I do not remember the length of the onstream period
593 on the Fleming stills, but I believe they were two or three times longer than for Burton. The charge for these stills must be a distillate stock.

In the operation of the Cross units a distillate was never separated and returned with the fresh feed to the entrance of the pipe heater.

In the low level runs the length of the run was determined by the amount of carbon that would deposit
594 in the chamber or by some other part of the operation going wrong. We tried to have a regular operating schedule but could not always stick to it.

"Q. On your cross-examination, referring to the observation you made of the Dubbs still as operated at Independence, you were asked whether you remembered how much gasoline was in the charging stock, and you said, 'I wasn't very much interested, really, in the results of that plant.' Just what did you mean by your statement that you were not interested in the results of the plant?

"A. I was not interested in the results of the plant, as it was built there, because I considered the plant as being not very well designed, and I was more interested in the principle of the process than in the products as they were actually obtained in that particular plant.

"Q. You mean the mechanical construction was not well designed?

"A. The mechanical construction was not well designed.

595 849 "Q. But did it fully exemplify the process or the principle of the process which afterwards came to be known as the Dubbs process.

"A. It did.

"Q. And did it fully exemplify the principle of the process and the process which was afterwards practiced in all of these plants, practically all these plants that you have referred to as Dubbs process?

"A. Yes, it did."

The charging stock used at Independence was supposed to be normal gas oil which would not contain any gasoline. Although I testified that the reflux ratio was high in the Independence apparatus, I do not recall the reflux ratio.

596 "Q. You testified on your cross that you were interested only in one point of the Dubbs process. What was that point.

"A. That point was not returning any of the cracked residue to the cracking coils."

850 *Recross Examination by Mr. Thiess.*

597 The furnace of PX524 was a furnace which we used in our own Trumble converter experiments. That would take it back to about 1915.

In the Cross operation, in Roxana in 1921 and 1922, we never mixed in our charging stock to that still any of the distillate that did not come in the gasoline range which we got from our pressure distillate obtained on
598 the Cross operation. We did it later on after we modified the plant by adding some towers to it, which produced various fractions of distillate, those fractions that corresponded more or less to the quality of the raw material charged to the Cross stills were experimentally added to the raw charge.

The dephlegmating equipment that we used there was not of the same type we recommended and used on the Dubbs still. The principal difference is that it was just a regular bubble tower equipment. The effect with the bubble tower was a little different because it did not run under the pressure of the cracking
599 plant. It was a fractionating plant hook-up.

When we were making the synthetic crude in the Cross operation, as we originally operated it before

we put on the dephlegmator, those fractions of that synthetic crude that were not in the gasoline range but in the gas oil range were experimented with. We returned that to the raw oil storage for our Cross plant. We mixed this gas oil fraction from the synthetic crude with our charging stock and used that experimentally in the Cross still when we were operating these
851 stills at Roxana around 1921 and 1922.

"Q. That was when Dubbs and Cross stills were both being operated at Roxana?

"A. Yes, experimentally.

"Q. This Cross operation was a widely used process, licensed by the Gasoline Products Company, wasn't it?

600 "A. It was used in other refineries also.

"Q. And that is about the time that you were experimenting with it in 1921 and 1922 at Roxana, isn't that correct?

"A. As far as I remember, it was used in a few other refineries. It was new at that time."

852 RICHARD W. HANNA:*
514 Roehampton Road,
Hillsboro, California.

Direct Examination by Mr. Hall.

601 I am Vice-President of the Standard Oil Company
602 of California. I have been associated with the company since 1911, and my duties have been concerned with the refining of crude oil, including cracking.
603 The crude oil refining capacity of the Standard Oil plants in California approximates 100,000 barrels per day.

Standard Oil Company of California's Use of Bur-
604 ton Shell Stills and Burton-Clark Stills: Cracking operations to produce gasoline as a primary product began in 1917 in ten Burton shell stills like that shown in PX504. These operations were unsuccessful in that

* Deposition given October 27, 1936.

the cost of production of gasoline, twenty-five cents per gallon, exceeded our realization of sixteen cents per gallon. The total cycle of the Burton shell was thirty-six to forty-eight hours, of which half was the producing period and the balance was for charging the still, cleaning out the carbon, and starting up.

PX 505A is substantially the Burton-Clark still that
605 we operated for about a year in 1918 or 1919, to compare with the Burton shell. The Burton-Clark was not a practical commercial operation for us. The total
606 cycle did not exceed sixty hours, with a thirty-six hour production period, the balance consumed in cleaning the tubes and shell, starting up and shutting down.
607 The pressure on the Burton shell still was 80 pounds and on the Burton-Clark tube still, 105 pounds. The on-stream temperature on the Burton shell still was 750 to 760° F., and on the Burton-Clark tube a
853 little higher. The Standard Oil Company of California had a license to operate the Burton still and the Burton-Clark still, which included the right to operate under all of the Texas Company patents.

608 The Hanna Still: After the Burton operations we attempted to improve the results by a forced circulation unit called the Hanna still. In the Hanna still we circulated dirty cracked residuum by means of a pump through the heating unit and shell. The arrangement of the heating tubes pump and shell are illus-
609 trated in the Halloran and Strout patent No. 1,765,976, PX 532. Thirty-five of these Hanna stills were built and operated, but were found not commercial.

The Modified Richmond Still: The next develop-
610 ment was to insert baffles in the Hanna still in an attempt to have less dirty oil go through the cracking coil. This was in 1923, and was called the modified Richmond still. It is described in the Halloran and Strout patent 1,765,976. The modified Richmond still
611 was a slight improvement over the Hanna operation but was not commercial.

Cost of Experimental Work on Cracking Problems:
612 At this time we had spent upwards of five millions of dollars and employed around two hundred technical men in experimental and laboratory work in an at-

tempt to solve our cracking problems. The cost of maintaining this laboratory was a million dollars a year, and I had the full responsibility.

License Negotiations Between Standard Oil Company of California and Universal Oil Products Com-
613 pany: Witness was asked what was done after the work on the modified Richmond still, and he answered as follows:

854 "At that point we observed a unit operated at the Martinez plant of the Shell Oil Company, a Dubbs unit, which we were allowed to visit, and there observed absolutely clean circulation, and we immediately realized that is what we were after and started to work on that line of development."

A report of this Dubbs operation was made to me and as a result I wrote a letter to Mr. Mason dated October 4, 1923:

614 PX 533. The following is a portion of this letter:

"In studying over these reports, it would seem to me that we have picked up the following:

First: Cleanliness is next to godliness.

Second: That the Dubbs people anticipate us in appreciation of cleanliness.

Third: That circulation can be obtained without the use of a pump.

Fourth: That higher pressures are very desirable.

Fifth: That it is questionable whether we have to have gill rings on our heating element.

Sixth: That if the maximum degree of cleanliness is
615 maintained, higher furnace efficiency can be attained."

616 PX 534: This is a report which Mr. Hamilton made to me on the Dubbs operation at Martinez.

(Abstract of Exhibit): The unit is described in some detail and the conditions of operation are stated, including temperature, pressure, operating time, and quantities of feed and products. A tentative estimate of costs is given.

617 PX 535 is a report from Hamilton to me giving the heat demands of the Dubbs cracking stills, and refers to a blueprint:

PX 536, which shows Mr. Hamilton's proposal of an additional baffle in the Hanna still.

855 After our inspection of the Dubbs unit at Mar-
618 tinez, we started to modify the Richmond stills into

clean circulation units, but this work was arrested by the issuance, in March 1925, of the Dubbs overhead feed patent No. 1,488,325, PX 537, which disclosed the clean circulation that we had in mind, and we asked our patent attorneys to pass on the matter before we went any further. As a result of that investigation, Lyon and Lyon, our patent attorneys, brought to our attention an earlier patent, Dubbs 1,392,629, issued October 4, 1921.

621 PX 538 is a letter from Mr. Adams, employed by our company in the capacity of superintendent of pat-
622 ents, calling to my attention that the Dubbs patent No. 1,392,629* is broader in scope than Dubbs 1,488,325,
623 and points out that under our licenses with Indiana we are licensed under "this Holmes, Manley and Behimer application which is in interference with Dubbs early and broad patent."

624 Prior to receiving PX 538, I had a meeting with Adams, Lyon and Lyon, and others, and the control of this patent over what we were doing was pointed out to me.

PX 539 is a letter from Lyon and Lyon to Mr. Adams which came to my attention. A portion of this letter reads as follows:

627 "The Dubbs patent 1,488,325 is not thought by Mr. Howard to be of any great importance. The earlier patent No. 1,392,629 granted to Dubbs on October 4, 1921, is of much greater scope and significance. This Dubbs patent 1,392,629 discloses and claims quite broadly the first above mentioned sub-type of the 'once-through a'tube and tank' process. This pat-
856 ent is involved to some extent in interference proceedings that are now pending in the Patent Office with The Texas Company and possibly others. We are endeavoring to obtain from the Patent Office any available information concerning this interference, the difficulty being that such proceedings are not open for inspection. This Dubbs patent 1,392,629 does not disclose introducing the new stock into the top of the fractionating tower or dephlegmator for heat exchange and condensation purposes. This is the new feature in

* This is the Dubbs patent in suit.

Dubbs patent 1,488,325 and to which said latter patent is limited."

629 Our attorneys, Lyon and Lyon; gave us an opinion on the validity of the Dubbs 1,392,629 patent and its bearing on the modification of the "modified Rich-
631 mond" still, whereby clean circulation was obtained. We sent for Mr. Halle* who arrived in July of 1924. We spent several weeks trading and negotiating, and I attempted to get rights under the Dubbs 1,392,629 and 1,488,325 patents for as little as possible, but Mr. Halle refused and I finally agreed to a license on Mr. Halle's regular basis, which included a license not only under these patents but under others as well.

During these negotiations Mr. Halle brought to my attention the Jesse A. Dubbs patent 1,123,502, but I was not interested in that patent or others referred
632 in PX 540 because my only interest was in the 1,392,629 and 1,488,325 patents.

As a result of the negotiations with Mr. Halle, the Standard Oil Company entered into a license agreement, PX 540:

(Abstract of Exhibit): The license agreement is dated August 15, 1924. Universal grants Standard a non-exclusive license under five patents and twenty pending patent applications, and Standard agrees to pay a royalty of fifteen cents (15¢) per barrel of oil treated under the license. Universal gives Standard the right to use any improvements acquired by
857 Universal. Standard's throughout under the license is limited to 200,000 barrels daily. A minimum royalty of $20,000 annually is provided. Universal agrees to hold Standard harmless against any infringement of patents owned by others by reason of Standard's practices under the Universal license and to defend any suits brought.

PX 541 is an escrow agreement which provided that the license agreement PX 540 was not to become effective until Universal had conducted certain tests which met certain quarantees as to the output.

---

* Mr. Halle was and is the President of Universal Oil Products Company.

PX 542 is a supplemental license agreement, dated
633 Aug. 15, 1924, extending the license agreement, PX 540, to subsidiaries of the Standard Oil Company of California, providing for automatic reduction in royalty to equal that of any more favored licensee, and waiving and releasing all claims for past infringement.

PX 543 is an agreement dated August 15, 1924.

(Abstract of Exhibit): The agreement enumerates the United States letters patent and applications owned by Standard and refers to corresponding patents or applications in thirty-three foreign countries. Standard assigns these patents and applications to Universal for a consideration of $4,000,000 reserving for itself and named subsidiaries the right to use the patents. The consideration of $4,000,000 is to be paid in monthly installments in amounts equal to twenty-five percent of the total of all payments received by Universal from Standard for royalties under the license agreement PX 540, Universal being under no obligation to pay any portion of the sum of $4,000,000 except out of payments under royalties paid from Standard to Universal under the license agreement. PX 542 provides that after full payment of the purchase price of the Standard patents, as fixed in PX 543, the future royalty rate is permanently reduced by one-fourth.

634 PX 544 is an agreement further defining the license agreement.

(Abstract of Exhibit): Standard's right to "improvements" under the license agreement does not cover chemical or catalytic methods or processes.

858 PX 545 is an agreement dated August 15, 1924, which excludes certain charging stock from the royalty payments.

PX 546 is an agreement dated April 27, 1925, which covers a diminishing royalty scale based on throughput.

PX 547 is an agreement dated April 30, 1925, which states that the computation of the diminishing scale
636 will be based on the combined throughput of the Standard Oil Company and its subsidiaries in the United States.

PX 548 is an agreement dated March 1, 1926, and refers to a waiver of certain monies due under the license agreement, PX 543.

PX 549 is an agreement dated January 29, 1929, and is an amendment further diminishing the sliding royalty scale.

Pursuant to these agreements, the license agreement, PX 540, was put in escrow awaiting the result of a demonstration run made at the Associated Oil Company plant at Avon, California.. These test runs ful-
637 filled all the requirements of the agreement and the instruments were taken out of escrow and delivered to
638 the respective parties in May 1925.

The Standard Oil Company of California thereafter
639 erected eight Dubbs units at the Richmond plant and seven at the El Segundo plant. PX 550 is a flow dia-
640 gram of the first unit built under the Dubbs license. The dot and dash lines show a "flashing" operation, which was not part of the Dubbs patent. The exhibit shows alternate methods of operation, but all setups include clean circulation. The alternate arrangements were provided so as to compare the straight Dubbs operation with our improved method of operating Dubbs. PX 551-A and PX 551-B are photographs of the Dubbs unit shown on the flow diagram, PX
859 550.

641 Referring to PX 550, the oil was heated in the tubes in the furnace and discharged into the vertical
642 evaporators. Vapors and gas were discharged from
643 the top of evaporators to the fractionating column and then passed on through the cooler into a receiving drum and to storage. The cracked residuum was removed from the bottom of the evaporators and never returned to the heating coil. The vapors in the fractionating column were cooled by the incoming feed and
644 a portion of the vapors were condensed, forming reflux. The reflux and feed from the bottom of the fractionating column were returned to the entrance of the heating tubes.

The pressure maintained throughout the system was
645 270 lbs., and about the end of 1925 the oil temperature at the outlet of the tubes was around 900° F., i. e., 875-910° F. The charge used was gas oil and the yield obtained was 40 to 45 percent of 437° F. endpoint gasoline.

We made no "non-residuum" runs because we had a large fuel oil market. The residuum was made into a commercial fuel oil.

647 At the conclusion of the demonstration run of the Dubbs unit, the modified Richmond installation was salvaged and the Burton shell stills and the Burton-Clark stills were junked.

The runs on the Dubbs stills were standardized to end at six hundred hours for inspection for safety. Such inspection disclosed some carbon in the tubes but not sufficient to cause a shut-down.

648 The royalty initially paid amounted to $2,500,000, and was based on the daily throughput, but sub-
860 sequently a paid-up license was taken for $3,000,000.

861 The total payment made by the Universal Oil Products Company in connection with the purchase of the property that was acquired from the Standard Oil Company under the agreement, PX 543,
649 was $600,000, and not $4,000,000, as provided by the agreement, and nothing further is due under that agreement. We considered, and still consider, that we have not received sufficient money for the inven-
650 tion covering the flashing set-up which was sold to Universal under that agreement, which at the time of the agreement was in application form. Said application in the name of Halloran and Strout was filed March 21, 1927, serial number 176,990, and forms PX 552.

862 *Cross-Examination by Mr. Thiess.*

651 While I was manager of refineries and superintendent of the Standard Oil Company of California, I was
652 acquainted with and directed the experimental work. I was closely acquainted with the development work that Halloran and Strout were doing.

We paid $3,000,000 for a paid-up license under the Dubbs patents in June 30, 1930, and at that time my company acquired an interest in the United Gasoline Corporation, which owned the Universal Oil Products
653 Co. I think that this United Gasoline Corporation was created at that time and now owns the Universal Oil Products Co.

The voting stock of the United Gasoline Corporation is new held one-third by Standard of California, one-sixth by Gulf, and one-half by Shell.

654 Our original license agreement with the Standard

Oil of Indiana was before 1918, and as a result we were in a position to utilize the development in the way of patents and patent applications of the Texas Company.

655 In our operation of the Burton stills, which we constructed in 1917, our procedure was to try to take
656 a predetermined percentage of something less than 40 per cent off of the original gas oil charge. We never charged any oil other than gas oil of approximately 26 gravity. There was so much carbon collected in gas oil charges that it was obvious that fuel oil would not run at all. It was our opinion that fuel oil in a Burton still was a larger carbon producing stock than gas oil.

657 863 The residuum from the Burton stills was sold as fuel oil after being mixed with our other residuum. We never attempted to distill that residuum, to get an additional charging stock for our Burton stills. The carbon deposited in the Burton shell at the end of a normal run was a very appreciable
658 amount. That was the direct cause of most of the shutdowns.

The charging stock which we used had a sulfur content as low as we could hold it. This sulfur content gave us some trouble as to the corrosion of the metal of the Burton shell.

659 As time went by, we reduced our pressure to maintain a proper factor of safety, from 80 pounds to as low as 40 pounds. The deterioration of the tensile strength of the shell stills was due both to the scraping of the bottom of the shells and corrosion due to the sulfur content in the oil. Both were appreciable. A
660 large part of the deterioration in the fire sheets was caused by the scraping. We had the same corrosion difficulties with all of the units, including the Dubbs stills, until we started chrome plating to protect the iron from the sulfur gases. We did not use chrome plating on the Burton shell stills. The reduction in
661 pressure to 40 pounds on the Burton stills reduced our yield. As we reduced pressure the hydrocarbons in the shell still would boil up into the tower and return, resulting in a very great loss of heat. That materially increased our cost of production which already was high.

662 We operated these Burton stills about a year. We operated at 80 to 95 pounds pressure for at least six months and then had our engineers give us a new working pressure of 40 pounds when we became frightened. During all this period the oil temperature was 750-760° F.

663 864 In the Burton-Clark still we used the same charging stock that we used in the Burton shell
664 stills. We did not withdraw residuum during a run. We withdrew the residuum at the end of the run when we shut down and sent it to the fuel tanks. Our regular running method was exactly the same as with the Burton shell. Of course we experimented on many runs. This Burton-Clark still was mostly run on as nearly a commercial operation as we could make it, comparing it to the Burton shell. The temperatures and pressures used were slightly higher; that is, 105 pounds pressure and a few degrees higher in temperature.

665 The yield on this Burton-Clark still was a little higher than our Burton shell. The Burton-Clark was not commercial because not profitable, due to low yield, low production per dollar investment, high cost of operation and short time on-stream.

666 I know that Burton-Clark stills were being used
667 many places, but I don't know whether they were profitable or successful. I do not think any of the refineries in California were using Burton shells, or Burton-Clark stills. We aimed for a standard run in this Burton-Clark still and mostly we shut down before we had attained our objective of 36 hours on stream.
668 In the operation of this Burton-Clark still we fed overhead during the operation. At the end of the run the carbon was deposited in the tubes and in the shell of the drum. A very considerable amount was in the tubes. It was shut down in almost every instance with hot spots in the tubes. I can remember very definitely
669 of scaling of carbon upward of one-eighth of an inch in the tubes at the end of a run. I remember them
669 865 wheeling away wheelbarrows of carbon from the shell. In the tubes the Carbon was very hard and in the shells, much softer.

670 It was easier to remove the carbon from the shell in the Burton-Clark than to remove the carbon in the Burton shell still.

700 The yield of the Burton-Clark still and other data regarding the same are:

Charge 12,600 gallons;

Fed in 15,400 gallons;

Naphtha or pressure distilate 16,950 gallons;

701 Feed in gallons per hour 475;

Naphtha in gallons per hour 522;

Naphtha produced based upon total charge including the initial charge and the feed, 60 per cent.

Crude gasoline products from total charge and feed, 30-35 per cent.

Temperature of evaporator, 730 to 770 F.

Pressure, 80-100 pounds.

Cycle time, 70 hours.

On stream, 30-34 hours.

Idle, 40-36 hours.

671 The forced circulation still developed prior to the Halloran-Strout to overcome the problem of the Burton and Burton-Clark stills was, in effect, the same as if a pump was put in the inlet end of the Burton-Clark still; instead of depending upon thermo siphons, there was a forced circulation. That was the principle involved.

672 Hanna patents, No. 1,419,378 (DX 553), 1,449,226 (DX 554) and 1,449,227 (DX 555) are patents on the work I had reference to.

672 .866 On this forced circulation Hanna still, we used a pump. Undoubtedly, that materially increased our circulation through the tubes, but that did not materially help any in the operation of the process.

673 Our theory was to keep the pipes clean and to prevent the deposition of carbon in the heating element. The coils were so designed that as the cracking started to take place we wanted the velocity of the mass and liquid and the cracking vapors and gases to create a turbulence or froth and go through so rapidly as to prevent the deposition of any carbon. We felt that we knew in 1919 and 1920 that the condition inside of that coil was a mixture of all, but we did not make and experiment to actually determine that. But our designing engineers substantiated our belief with their design and development of their design, in the pressures that

674 were obtained in their tests. That is the only kind of proof of increased velocity that I can recall. This

increased velocity did not help any in the operation of that still—not sufficient to make it commercial. It was an improvement in that it ran a little bit longer.
701 The Hanna still had an on stream period of 70 hours of a 100 hour cycle. The crude naphtha yield was 35% of 45° gravity. The crude gasoline was 20%.
674 We used two kinds of pumps, centrifugal and remote plunger pumps for this purpose. The oil that these pumps were pumping was around 750 or 760. We did not have any material or mechanical difficulties in
675 pumping oil at this temperature with a centrifugal pump which we developed. The operation of the plunger pump was for the most part poor.

On the ports, in the centrifugal pump, we had trouble with the carbon originally. We did not overcome that on that unit. That was not the thing that shut us down, as a rule.

675 867 I think that a pump man named Lane took out some patents for this centrifugal pump. At that time a pump to pump hot oil at the pressures we were
676 using was a novelty, was something that had to be developed.

We built 35 Hanna stills. Their cost was not in-
677 cluded in the $5,000,000 which we spent in development work. I cannot say what part of the development work that was done on the Hanna still was included in that $5,000,000. We built a unit and did experimental work until we finally thought we had a commercial still, and that expense would be naturally included in the development work. When we finally got to the place where we thought we had produced gasoline on a commercial basis, then we built the thirty-five stills. In the experimental work that we did on the forced unit we did not get to the point where we were making gasoline on a profit basis, but we figured that we had the experimental work to a point where it would produce gasoline on a commercial basis, or we would not have spent money on the construction. Obviously the records must have pointed to the fact that the still
678 was going to be commercially successful.
679 The experimental units which we built were semi-commercial. They were good sized units about half the size of a plant unit. On a unit of that size we would know when we projected it into a commercial still

whether it would work and we proved it. Twenty of
680 those stills were at Richmond and fifteen at El Segundo. We did not operate those commercial stills at Richmond very long.

After we got through with this so-called Hanna de-
681 velopment, the next development was the still which is disclosed in the Halloran and Strout patent No. 1,765,976 (PX 532). This Halloran and Strout operation was developed in the latter part of 1922 and early part of 1923. I was pretty close to this develop-
682 868 ment and was sufficiently familiar with it so that, at the time the specifications for the patent for the Halloran and Strout operation were prepared, I believed the statements contained in the specifi-
682 869 cations to be true and correct. The Halloran and Strout operation was called the modified Richmond arrangement.

After we had seen the Martinez operation we planned
683 on switching over from Halloran and Strout. We got out our drawings and our plans, but before we made a move to change them we were licensed under the Dubbs and started from the ground up again. We never changed the Halloran-Strout or modified Richmond still, to one in which we did not return any of the residuum to the heating tubes. I am not sure whether we closed up one of the baffles at that time, or whether we were stopped from doing so by these patents.

684 It was a single unit at Martinez which our organization saw but I never saw it. Our men were over there to observe this unit during just one run (PX 533); the Hamilton letter of September 8, 1923, is the only report we have on that. This observation was
685 made just prior to this letter, on September 7.

In the Root case I testified:

"Mr. Halloran was our research man. After that communication was sent to Mr. Halloran of the research and development department, we immediately started to convert our so-called baffle stills to absolutely clean circulation in not returning any of the cracked oils coming from the output of the tubes back into the inlet of the tube, but feeding merely with clean fresh feed and the clean reflux from the tower to the tubes. In comparison with what we have done theretofore we found it solved our carbon troubles. I am

speaking of the 15 and 20 units I have mentioned several times converting them."

870 That does not change my understanding about the conversion of these stills. We started to convert them and we were stopped in our conversion by this patent situation.

My two statements mean the same thing to me. When we discovered the clean circulation, which we found out at the Martinez unit, we threw our hands up in the air and gave a cheer, that we had found a solution to our problem, and we immediately went to work to get out our plans and designs to convert the 15 and 20 units. I did not say here that we had completed them. I know that we did not complete the 35.

688 I do not know why, when we made the test runs, we went to Avon rather than going back to Martinez. Arrangements were made for the test runs by the Universal, and they probably found that it was easier to get these units turned over to them at Avon. I know nothing about the Martinez units, except the report that I got from Mr. Hamilton.

689 The runs at Avon were made by our men under the supervision of one or more Universal men, and probably with some Associated man at the plant.

690 PX 550 shows the flow of the regular Dubbs as we originally installed it in the first unit. The engineering designing on that was provided largely by the 691 Universal Oil Products Company. The contribution of the Standard Oil of California was not only the flash operation. I imagine that our hot oil pump experience was employed, maybe the key headers that we used were employed, valves and miscellaneous little things, but the principle was not changed. The apparatus in which the operation was carried on subsequently was probably not modified from that shown 692 on PX 550. All of our Dubbs units had a flash 871 chamber as shown on Unit No. 1, on PX 550, 693 connected to them and operated only in that way. There was no difference in the furnace of the units used for the flash and the one used for the regular Dubbs operation. There was no heating plant to the flash unit. The furnace, itself, would be the regular design at that time.

The Universal would have had somebody there for supervision of those first runs made of these Dubbs stills that were installed at the Standard Oil of California, and we had our own superintendent there, and all of the rest of us were probably standing right by watching.

694 If the Universal representative was there, he probably stayed until we said we could run them. After
695 that we permitted the Universal representatives to enter our plant at all times. Without doubt, the experts of the Universal helped us in the way of instructions as to how these stills should be run. Undoubtedly he told us when to build the fire, and how rapidly, and all of the details of operation.

We also operated at our plant a so-called Cross
696 unit. I don't know as to the financial side of it, but it did not compare with the Dubbs because the unit was under a high pressure and we could not charge as heavy a gravity charging stock because it carbonized both in the tubes and in the drums. Also it had lower capacity per hour of gasoline, and, economically, it was not in the same class as these other units, so we converted it to a Dubbs unit.

In the operation of this Cross unit, the residuum was withdrawn from the still and not returned to the tubes. The feed was light oil. We operated this
872 Cross still a sufficient number of times to satisfy ourselves that it did not compare in efficiency
697 with the Dubbs principally because of the filling up with carbon, and shutting down, and not producing the quantity per hour.

As of the time that I negotiated for this Dubbs license in 1924, other cracking processes on the market that I knew of besides the Burton, the Burton-Clark, the Cross and Dubbs, that were being operated, was Cosden who had an installation of units in which they did not condense under pressure in order to avoid
698 the Burton process. I possibly heard of the Isom Sinclair process at that time. I knew of the Holmes-Manley process. I did not know anything about the operation of the so-called Hall process commercially. I knew of the Rittman process, which was a process gotten out during the war.

I did not investigate, or do any work in connection

699 with, the so-called vapor phase processes prior to 1924. I did investigate the Rittman and felt that it was not suitable for our purpose. We did not try to use that process. Doctor Manan, at that time our chief chemist, investigated it and turned it down as impracticable.

706 In the stock that we used, that had this sulfur content, that sulfur content in the stock required in treating a higher acid to reduce the sulfur to a standard for gasoline. It made it more expensive.

In the operation of DX 556, which shows the Hanna or Richmond pressure still, the oil was heated in the coil in the furnace. The oil was forced through the coil with a centrifugal pump back into a 10 x 30 shell. Gas vapors were run off the body of the oil in the shell, up through the dephlegmating tower,
873 through the planer, through the condensers to the receiving house, where pressure was controlled and released, the cracked naphtha going to storage. The reflux and feed, which later was projected into the tower, although not shown on this drawing, returned through the reflux line to the body of the oil in the shell. The tar was withdrawn through the heat chamber or tar cylinder to storage.

707 In this surface, although not shown, the burners were probably where I have marked "X." The burners discharged their flames into a combustion chamber, the heating tubes in the furnace being enclosed in a convexion chamber which was divided from the combustion chamber by a bridge wall marked "Y." This construction with the bridge wall was utilized in order to protect the tubes from the flames of the furnace. At that time we thought that that was an important consideration in the cracking operation in the design of the furnace.

709 The connection marked "Z" is the pipe that leads from the bank of tubes in the convection section to roof tubes marked "W." The arrows show the flow in that direction. These roof tubes would be subject to radiant heat in the furnace. As I remember, the purpose of using these radiant tubes in this furnace was for fuel efficiency.

710 This reflux and vapor return line marked "A," that is extended through the inside of the shell and

is brought over to a position right above the part marked "B," which is used to withdraw hydrocarbons from the tank to the centrifugal pump.

The purpose of bringing this line through this chamber and placing it directly over this pipe "B" was in trying to maintain dilution in the circulation, that is, trying to get all of the reflux and feed into the pump and heating element with as little of
874 the cracked oil as possible. We thought this par-
711 ticular construction assisted the operation in that respect at the time.

I do not remember the development leading up to that method of returning the reflux. We may have operated without it, or it might have been on the original design.

The pump shown on DX 556 is a centrifugal pump,
712 and handled oil at temperatures from 760 to 770, and pressure of 80 pounds. There would be a higher pressure on the discharge side of the pump.

713 The liquid level was maintained slightly above the suction level. That was a considerable amount of oil; the chambers were possibly half full.

The residuum withdrawn from this tank was about 20 to 22 Baume gravity. The residuum went to the fuel oil tanks. We did not, as a practice, atmospherically distill this residuum.

714 At the end of a run we had a very serious amount of carbon in the tubes which controlled the length of time we could operate, and also a part was deposited in the shell. I don't remember the relative quantities. We set our length of run to the maximum that the carbon deposition in the tubes would permit, that is, we ran these stills until we got hot spots.

715 We attempted to run for a certain length of time. Invariably hot spots started to appear earlier than that, but if we thought the hot spots were not so serious as to cause a tube rupture, we might have continued occasionally, and did continue until the standard time had elapsed. If the fireman and shift foreman thought the hot spot was serious the authority to shut down was left in their hands.

717 875 1921 to 1923 substantially covers the length of time that the Hanna stills were operated.

721 The commercial operation of the Richmond stills

of PX 556 was not exactly as good as the experimental because we probably took more chances, and did not need to have so much oil under pressure and temperature and consequently went beyond what would be a safer condition in the larger units.

I don't recall whether in our experimental work, we used that feed and reflux line which has been identified by the reference letter "A" on DX 556. We actually made the changes in this Richmond pressure still of DX 556, which were later incorporated in our operation and known as the Halloran and Strout operation.

722 DX 557 and DX 558 are two drawings of the Halloran and Strout operations.

723 These two drawings show the so-called baffle improvement. On DX 558 the baffle which I have marked "A" was placed in the suction end of the shell, which tended to separate the liquid in that end of the shell from the liquid in the balance of the shell. An opening was left in the bottom of this baffle so that the surplus liquid returning from the circulation could flow into the balance of the shell. I have marked that "B." The shell holding the main body of oil had additional loose baffles marked "C" and "D." The vapors rising from the forward compartment passed through the vapor lines which went through the forward baffle "A" releasing the vapors in the back chamber.

These vapor lines were perforated for that purpose and are marked "E." The feed and reflux was
724 conveyed into the front compartment by the line marked "F." The line "F" in DX 558 dis-
876 charged directly over the suction to the pump, whereas in DX 557 this return line merely went through the tight baffle.

In the operation of this modified Richmond or Halloran and Strout still, I assume we first operated with a chamber in accordance with DX 557 and later in accordance with DX 558.

The difference in dates on the two drawings, namely 8/30/23, and 1/22/24, would indicate how long a period this modified arrangement according to the showing on DX 557 was utilized.

725 The apparatus in which the Halloran and Strout,

or modified Richmond, process was operated was substantially identical with the Hanna apparatus of DX 556, except for the modified chamber illustrated
702 in DX 557 and 558. In this still the charge was 26 gas oil gravity from which a P. D. having approximately a 50 gravity was produced, which was approximately 48 per cent. of the charge; from the P. D. approximately a yield of 39 per cent. Based on the charge crude gasoline was recovered. The recycle stock from the front compartment had a gravity of 20 degrees Baume, and the residue drawn from the rear compartment has a gravity of 17 degrees Baume.

All the Hanna stills were converted in 1923 or 1924 into the Halloran and Strout type, and they were all abandoned by December of 1925.

In the operation of these stills the average on-stream period was 70 hours and the complete cycle was from 90 to 95 hours. The word "cycle" as I have used it connotes the period from charge to charge in the operation of the still.

725 877 PX 532 represents a flow diagram of the way the Halloran and Strout process was operated at the Standard Oil Company of California. There are vapor heating chambers there which I do not recall
726 if we put in. We operated with solvent oil a few times. I do not think that solvent proved out as of any material value, so we did not continue having a separate solvent feed. The cost of all experimental work was charged to the $5,000,000 which I have previously referred to. If we experimented with that solvent
727 oil that was charged to it. When we did any changing in our regular operations in the nature of experimental work that would be charged to experiments.

Referring to PX 532, Halloran and Strout patent No. 1,765,976, Fig. 2 shows a high oil level in the compartment 12, which is the rear large compartment, and a low level in the compartment 10, which is the front compartment. I think our commercial operations were conducted with the level in the front compartment lower than the rear compartment but I cannot say whether Drawing Fig. 2 properly reflects the levels that we used commercially. I do not know what the difference in levels would be now.

728 The withdrawal of the charge and vapors and bank-

ing of the vapors in the front compartment only would effect a slight difference in level in the two ends of the drum. The greater part of the vaporization which occurred in the process was effected in chamber 10, the front compartment and it is my idea of what occurred that the vapor thus formed in this front compartment held the level in compartment 10 lower than the level in compartment 12. The vaporization which occurred in this front compartment 10 was the re-
728 878 sult of the cracking that occurred in the heating element, and to a very large extent realized in
729 that compartment. Cracking also occurred in compartment 10 to a very much less degree. The pressure in compartment 10 and in the tubes was not the same; the tubes had higher pressure, with the friction and the cracking result that took place in the tubes.

Q. If the pressure in the tubes was higher you would get more vaporization in compartment 10 at the lower pressure, would you not?

A. The projection of cracking coming out in the mixed turbulent froth was released in this, and the separation of these cracked products would take place in that compartment.

Q. I do not know whether we exactly understand one another. Is it your understanding that as soon as cracking occurred vaporization occurred?

A. That is rather a technical question, but our belief was, and my belief still is, this, that 60 per cent of the cracked gases were generated and produced in the tubes, and that, say, 40 per cent of the
730 balance would be a result of the time element in the chambers 10 and 12. So that the 60 per cent that was created in the tubes would be released when it was expanded into compartment 10, and would pass out of that compartment through vapor lines. A little additional would be created from the body of oil in compartment 10. The balance would be generated or created from the body of the oil and soaking time element in compartment 12. As the cracking occurred in the tubes, vapors would be generated. The part of the cracking which occurred in the chamber 12 is the
731 result of the time factor that the body permits of.
731 879 How long it is I do not know. We also thought that we were adding heat to the vapor line and assisting our cracking in that manner. In other words,

we believed that our vapors were considerably hotter and would serve to assist to reduce the temperature drop in chamber 12, caused by the cracking reaction and vaporization there.

Q. Was the vapor which was released through the tubes 14 utilized to heat the oil, or was that vapor used more from the standpoint of creating a partial pressure effect to cause vaporization?

A. Our idea, as I look at it now, must have been heat rather than partial pressure, because partial pressure would convert more readily into a vapor.

Q. In other words, the partial pressure would take the liquid out of there and defeat the idea of time factor?

732 A. I do not see how it could defeat the time factor. The oil quantity in the compartment maintained a constant level. What the theoretical result would be would be a technical question.

Q. Mr. Hanna, because of the longer time factor that was maintained in chamber 12, it is true, is it not, that the main precipitation or settling out of the car-
733 bon, tarry bodies, or heavy derivatives or cracking takes place in this chamber?

A. As I said before, the relative quantity of carbon deposit, weight, I have no recollection of, but the carbon deposition that controlled our success or failure was that which deposited in the tubes. That is all I can say.

Q. Let me ask you, Mr. Hanna, do you agree, and when this patent application was drawn did you consider this statement on page 3, beginning with line 101, to be correct, reading as follows:

733 880 "The reacting oil is maintained for an appreciable time in this chamber 12 and the main precipitation or settling out of the carbon, tarry bodies, or heavy derivatives or cracking takes place therein. The period of reaction is thus prolonged by the reaction of the oil in the final evaporating chamber 12, as described, without permitting this prolonged reaction, and the consequent precipitation and settling out of the oil of the heaviest derivatives, to effect the
734 operation of the cyclic system, which includes, as before described, a heating zone or coil and a cycling chamber in which latter material vaporization is effected."

735 A. The normal manner in which I read a patent application was to read the claims, have it explained to me by the patent attorneys, and possibly the inventors, and release them to take out a patent application on the subject. I cannot say that I read the description of many of these patents, and, therefore, I cannot say now that I read this paragraph referred to, and
736 therefore cannot say that I agreed or disagreed with it.

Q. Do you agree with it now?

A. I am not competent to agree to anything on the technical side. It is a matter going back twelve years. During this period I have been away from the technical end of it. It is not a question that I would expect to be asked or to be expected to try to answer.

In this Halloran and Strout commercial operation, all of our residuum went to fuel oil eventually. It might have paused in two or three tanks, but eventually it got down to the fuel oil tanks. The temperatures and pressure that were used in the com-
736 881 mercial operation of Halloran and Strout would be approximately the same as the so-called Hanna operation. The carbon in the tubes was hard and difficult to remove. The carbon in the shell was relatively soft.

737 The purpose of the Halloran and Strout operation as compared to my previous Hanna operation was to reduce the amount of carbon that we were having deposited in our tubes. The way we hoped to effect that was by keeping the stock going into the tubes cleaner, from tarry, cracked bodies. We wanted the stream to contain the maximum amount of the clean residuum and charging stock.

Q. And you understood at that time, did you, that the return of residuum would cause trouble in the tubes, from the standpoint of carbon deposition?

A. Circulating carbon cracked bodies had given us
738 the carbon trouble.

Q. And you understood that the return of these cracked carbon bodies would give you that trouble at that time.

A. I think that I knew it very definitely.

The return of the residuum to the coil, that is, the part that we did return would give us a greater amount of pressure distillate; anything we put through the coil and cracked would give us more distillate.

The approximate cost of one of these Hanna stills
739 that I have referred to as the Richmond still is approximately a little over $100,000 per unit. This Halloran and Strout application, PX 552, and the patent that is to issue on said application were assigned and belong to the Universal Oil Products
882 Company. I believe we turned this application over to the attorneys of the Universal Oil Products Co., and they continued the prosecution. I cannot say accurately.

I understand that the Dubbs unit at Martinez was a commercial unit. PX 534 describes the Martinez unit and comments on the Halloran-Strout unit, bringing out that the Dubbs people realized the value of keeping clean stock in the tubes.

742 883 In PX 534, under the heading "Chamber", the statement is made that it will hold 26 tons of coke. The coke-holding capacity of this chamber determined the length of the run when running non-residuum. As I recall it, the Shell practiced non-residuum operation.

The coke-holding capacity of the reaction chamber
743 on a residuum run of the Dubbs operation, as practiced subsequently, never determined the length of the run with us, both in the flashing operation and the Dubbs operation without the flash in so far as we operated them. We operated without flashing comparatively little. I cannot say how many runs we made without flashing. Enough to satisfy us as to the relative advantage of the two systems, however.

In PX 534, under the heading "Pressure" he says, "The unit is operated at 120 pounds gage." The
744 pressures used by the Standard Oil of California, as indicated on PX 550, are much higher, of an order of 310 to 375. I think we actually operated with 270 pounds, and we went up in pressure to get the higher temperatures, on the recommendation of the Universal Products Co. from their experience in designs, for better yield and more efficient operation. The temperatures shown on this diagram (PX 550) at these pressures are 860 and 880 at the outlet of the coil. I don't think we ever operated at that pressure. The pressure indications on the drawing are not the pressures that we operated under in commercial operation.

745 Q. This drawing (PX 550) was produced, was it not, to show what you were doing commercially?

A. Not necessarily, from the detail standpoint as to the pressures that we were to operate on when
745 884 our engineers decided on the pressures, etc. It might well have been outlined as the objective; when the unit was constructed, the safety engineers would have to pass on the pressures we could operate on at that time.

Q. This drawing, then, is not a showing of the manner in which you actually operated, as far as temperatures and pressures and other indications of that sort are concerned?

A. This undoubtedly was not a record of runs, because we kept our records in another form. This, as it says here, is a flow diagram, indicating the method that we would operate, the principal that we were to use, and it does outline that.

270 pounds, as I recall, was the pressure that the safety engineers passed on. That pressure was pos-
746 sibly used both on the Dubbs and the flashing system, the same factor of safety controlled both in operation. We never did operate that Dubbs unit at lower pressures, not as a commercial practice.

749 On the last page of PX 534, the fourth paragraph from the bottom, he says: "You can see from the above that the equipment is very similar to ours, only that he does not use a pump to circulate." This non-use of a pump would affect the operation only as to the head on the inlet end of the coil. The differential of pressure across from the inlet to the discharge end of the coil is substantially the head required to overcome the friction through the system. In the case of the elevated gravity head of the Dubbs, it would all depend upon the height of the gravity head, whether
750 it equaled the pressure developed by the pump. A pump would give you positive circulation through the tubes as long as it operated. How that circula-
750 885 tion would compare with the circulation that you would get with an elevated dephlegmator would depend entirely upon the capacity of your pump and the height of the dephlegmator.

Q. Would you consider one better than the other, or are they equivalents?

A. I think we proved the pump the practical thing.
751 Referring now to PX 535, which is a letter of October 1, 1923, written to me by Mr. Hamilton, in the sen-

tence immediately following the tabulation of heat demand in B.T.U.'s, a statement is made that the "Velocity in tubes is approximately 3.7 feet per second". I have not got the velocity which the Standard Oil of California used in their units as exemplified
752 in Exhibit 550, where they used pumps, but I think it would be a considerably greater velocity in the Standard Oil of California operation.

This drawing, PX 536, was attached to the letter PX 535, and is referred to in said letter. PX 536 shows the Halloran and Strout unit previously described with a suggestion of Hamilton to keep the coke, that was formed and carried in suspension in the discharge from the furnace, from being picked up by the suction of the pump and returned to the heating element. This was one more step in an endeavor to keep the tubes clean.

It was proposed to put an extra baffle marked "A". and extend the discharge from the heating coil shown in dotted red,, which I will mark "B"; the discharge thus opening on the opposite side of this proposed baffle marked "A", from the suction which I have marked
753 "C". The hoped for effect was to settle out the carbon without letting it get to the pump. In the
753 886 blueprint the opening I have marked "D" was considerably off of the bottom of the shell, so as to give room for this carbon to come to rest.

754 I don't know now whether we ever operated according to the showing on this drawing. The furnace there shown and the rest of the equipment, except for the changes I have indicated, are the same, sub-
755 stantially, as the equipment shown in the drawing Exhibit 556, as modified by the chamber of Exhibit 558.

756 Under item 3 of PX 533 I said, "That circulation can be obtained without the use of a pump." By that I mean the elevated dephlegmator tower. I did not consider that advantageous in view of our development work on pumps. We had developed our centrifugal pump to a point where we believed that it was better than the elevated dephlegmator tower. Under item 4, I said, "That higher pressures are very desirable." I said that because higher pressures might have better efficiency in the fuel consumption.

757 In addition to the heat demand, higher temperatures would be possible and thus give more yield in the cracking operation.

We never practiced the Dubbs process, using an elevated dephlegmator other than in the experimental work at Avon. There I think we did not use the pump but used the elevated dephlegmator tower.

Since the other day I have looked up the question whether we ever actually made the changes in the Halloran and Strout still to incorporate any changes as a result of what we saw at Martinez and find that this work was only planned on the drafting board as shown by the drawing DX 559, and was not
757 887 put into operation in the Halloran and Strout still.

Referring to this drawing DX 559, which is the
760 drawing attached to the Halloran and Strout application, starting at the outlet of the heating coil the heated cracked oil was to have gone—I say that because this unit was not constructed—to the chamber
761 marked "A", the vapors rising from this chamber to the column marked "B", the naphtha vapors going on to the vapor line marked "C", to the condenser marked "D", to the receiver marked "E", where the gas was released and the naphtha delivered to storage. The residuum from chamber A was released into the tar flashing chamber marked "F", where the gas oil cracked was distilled by residual heat overhead, to vapor line marked "G" and condenser marked "H". As a matter of actually putting this into operation, the condenser marked "H" was not employed when we constructed, as we used fresh feed to condense this vapor, thus preserving the heat. The condensate from this flashing operation, together with part of the feed, was forced through the heating coil along with the balance of the feed which was injected into the tower and the reflux stock from the tower.

762 A temperature is given for the chamber of apparently 800. The temperature at the outlet would be a little bit higher.

In this drawing the furnace is shown conventional. The fire is indicated at the left-hand of the furnace. According to our practice up to that date there would have been a bridge wall in front of those tubes. Under those circumstances the feed to the coil comes in at the hottest part of the furnace and comes out at the coolest part. We did not operate this so the feed did not actually go in. When we did operate, as I
763 888 remember the later practice, we developed a furnace design to arrive at the injection of the new feed in the hottest part of the furnace. If we did this it was only to get better furnace operation.

This thing that we see here that is referred to as a jet pump is in dotted line. A jet pump is a type of pump for any purpose. As I recall, if the pump
764 marked "Secondary pump" which fed the oil to the coil should not deliver enough oil to the coil for the proper operation, then we would withdraw to the left for the baffle "Z" with our jet pump and cycle oil from the chamber through the coils and that would be until we could get the fire shut down and pulled out to keep from blowing up the unit.

765 I note that the condensate coming from the tar evaporator "F" comes down into what is termed the main feed line, and then in this main feed line there are arrows pointing toward a cycle stock storage tank, and an arrow pointing away from the cycle stock storage tank. It was not contemplated to run some of the cycle stock from the tar evaporator into a storage tank unless there was a surplus of it. When we actually started to operate the flash system there never was a surplus.

I have no opinions or correspondence other than I have thus far produced from our patent attorneys
766 on the Dubbs '325 and '629 patents.

Our patent attorneys advised us that the Dubbs patent No. 1,392,629 was at that time in interference with the Holmes, Manley and Behimer application, Serial No. 401,623. At that time our patent attorneys made such investigation with respect to
766 889 this interference, No. 49,355, as they could. It would be normal to do that before we sent for Mr. Halle.

767 I did not know that in the Behimer application the claims of the Dubbs 1,392,629 patent had been copied for the purpose of the interference. Our attorneys did not tell me that. I did not consult with The Texas Company respecting this situation to ascertain their position with respect to the Holmes, Manley and Behimer process and this interference. The attorneys may have. I do not know how far they went with their investigation. I only know that they advised us against disregarding the Universal Oil Products Co. patents and recommended to us that we had better get that coverage before we went ahead.

768 We were willing to take our chances on condensa-
769 tion under pressure, covered by the Universal Oil Products Company patent to Jesse A. Dubbs, because
770 we felt that we had the Standard Oil Company of Indiana as a buffer, first, and secondly, there was prior art which was sufficiently clear to us so that we felt the Jesse A. Dubbs patent would never be sustained. The other arguments that Mr. Halle used
769 as to his other patents were given but little weight in my mind, as I felt Mr. Halle was trading. Mr.
770 Halle brought up references to many patents, most of which we were familiar with. He referred to mechanical device patents, cleaning of still patents, and I took the position that if we did not have rights to any of those patents which I considered minor, we could possibly get around them. I told Mr. Halle this, to which he replied it would cost us a great deal more money to try to get around any of these patents.

The question as to taking chances on the Holmes, Manley and Behimer was distinctly different from
770 890 the others, in that our patent attorneys felt that we had to deal with Universal Oil Products Co., on these patents, whereas they advised us that we were taking no risk if we did not deal with Universal Oil Products Co. on the Jesse A. Dubbs, so that in both cases we were doing what our patent counsel advised.

772 In spite of what Mr. Howard and Mr. Adams stated

in PX 538 and 539 as to the possibility of Dubbs losing the interference, we were desirous to get protection under the two patents in question; the '325 patent, which included the fresh feed being preheated in the vapor column was also a vital part of our proposed operation, and the weight we put upon
773 the advice and the study is borne out by the fact that we later did sign a license agreement which cost a great deal of money, running into millions, and we did that with our eyes open as to the cost.

Company had acquired rights from the Dutch Shell

I think that when I discussed this matter with Mr. Halle he advised me that the Universal Oil Products to license or grant immunity under the Trumble patent No. 1,281,884.

Referring to the letter, Exhibit 539, from our attorney, Mr. Lyon, he again quotes Mr. Howard as stating "Apparently Mr. Howard knows of no definite ground of invalidity of Dubbs patent 1,488,325, and
774 believes that this patent will have to be avoided. Mr. Howard is somewhat concerned with the possibility of a suit being brought at some future date against us for infringement of Trumble 1,281,884 by The Shell Company. The Shell and Dubbs interests are apparently working together."

The Universal Oil Products Company only paid approximately $600,000 pursuant to PX 543 providing for a payment of $4,000,000 for Standard of Cal-
891 ifornia patents. The remainder of the $4,000,000 was not paid because we bought a paid-up license,
775 and if we did not pay any more annual royalties, of course, the payment for patents on the basis of a 25% refund was off.

Among the patents involved in this sale are five patents issued in my name, namely, patent No. 1,419,378, DX 553; No. 1,449,227, DX 554; No. 1,449,226, DX 555; No. 1,408,698, DX 560; and No. 1,655,603, DX 561. Those are some of the patents for which this consideration was paid.

776 In this transaction in which the paid-up license was purchased there were some notes issued at the time of the agreement. The Standard Oil Company of New Jersey took $3,000,000, the Standard Oil of Indiana

777 took $3,000,000, Halle retained $3,000,000, the Shell and the Standard Oil Company of California took $6,000,000 between them, I think, a total of $15,000,000. These notes were not secured by bonds. They were interest-bearing, to be amortized out of income from
778 the Universal Oil Products Company. We signed a number of patent immunity agreements. I do not know the detail of them now.

At the time that I discussed this license agreement with Mr. Halle I made a study of the Dubbs 1,392,629 patent.

Testimony Under the Rule:

Q. At that time, as a man skilled in the art, what
779 was your understanding of the teachings in the patent that the oil in the heating tube should be heated to a cracking temperature without substantial vaporization?

Mr. Hall: Now, your Honor, that is objected to as outside the direct examination, and irrelevant and immaterial. This man, of course, was not called as a technical expert. He was called merely to give fact
892 testimony as to what had been done by the Standard Oil Company of California under his directions; and his opinion as a man skilled in the art, which is here sought under cross examination, seems to me is wholly outside of the direct examination.

780 Mr. Thiess: Now, this man, this witness, was the man in charge of the technical development work of the Standard Oil of California. He is talking about the '629 patent in suit. He has said, "We had to take a license"; he has said that he made a study of this patent; he has said he got reports from the patent attorneys on this patent. If he did all this, then he certainly must have known and must have discussed at that time the very vital question as to what the phrase "without substantial vaporization" meant.

Mr. Hall: Your Honor, it made no difference what he thought about it.

781 The Court: I think the objection should be sustained; and the matter will be read into the record. Should I afterwards change my opinion when I come to read it, I will indicate it; but at this time my opinion is that the objection should be sustained.

782 A. It would mean during this heating in the tube there would be no separation from the mass or mixture

of oil gas cracked products of the vaporized constituents of this mass flowing through the tubes.

The effect of pressure in a cracking still is that it increases the boiling point of the liquid oil in the still.*

Q. And the use of atmospheric pressure would raise the boiling point and retard or prevent formation of vapor bubbles in the still, would it not?

784 893 A. As compared to employing super-atmospheric pressure, the effect of atmospheric pressure that you speak of would tend to lower the boiling point and thus accelerate the formation of bubbles and gas.

Q. As you increase the pressure don't you retard or prevent the formation of vapor bubbles?

A. Yes.

Testimony Not Under Rule:

"Mr. Thiess: 'Q. And would pressure have any effect or in any way tend to prevent the separation or liberation of the vapor in the tubes, such as the tubes of this Dubbs patent, in which a vaporizing surface is maintained and the vapor bubbles are free to rise from said surface?'

"Mr. Hall: I would like to read the objection, if your Honor please, in this case?

"The Court: The same objection?

"Mr. Hall: I would like to give the reasons.

"'The Court will notice that this is an attempt to examine the witness in reference to his opinion, whereas the direct examination was directed to the facts
785 connected with the history of the Standard Oil Company of California in connection with the cracking of oil leading up to the licensing of that company to practice the invention of the Dubbs patent here in suit in the cracking of oil. The witness was not examined as to his opinions or as a technical expert. This is an imposition upon this busy man, to consume his time in this way, more particularly as he is now involved in the dock strike which is on at the present moment in this city, where the operations of his company are carried on, and in connection with which his services are badly needed by his company.'

"In other words,—

"The Court: His time was taken up?

"Mr. Von Holst: Go on reading, Mr. Hall.

* This statement not under the rule.

"Mr. Thiess: Go on reading, Mr. Hall.

"Mr. Hall: 'The witness is now instructed not to answer this question until he is advised to do so by the Court.'

894 "Mr. Thiess: 'Q. Mr. Hanna, I wish to call your attention to your patent No. 1,449,226, Defendant's Exhibit 555. This is directed, is it not, to a cracking process?

'A. Yes.

'Q. I refer you particularly to page 2, beginning
786 with line 20, which reads as follows:

' "We take a charging stock, therefore, with a material range of boiling points; to wit, of not less than 200 degrees F., and in the primary heating keep such stock under such a pressure as to at all times during such primary heating prevent vaporization of any material portion of the charging stock whereby substantially all the charging stock is at all times during such primary heating retained in liquid form and cracking thereof substantially avoided."

In that statement do you use the word "vaporization" to indicate vapor formation?' "

787 "Mr. Haight: I was going to say that is the same question exactly that your Honor ruled out the other day.

"The Court: Yes.

"Mr. Von Holst: The witness was instructed not to answer, your Honor.

"Mr. Thiess: Instructed not to answer.

"Mr. Von Holst: So there is no question before the Court.

"The Court: There is nothing in the record.

"Mr. Thiess: But we would like the record to show that this witness was instructed not to answer.

"Mr. Hall: Of course the Court will have in mind that counsel had an opportunity at that time to certify that question to the Court that would have issued the subpoena and had it ruled upon, and he did not avail himself of that opportunity.

"Mr. Thiess: Counsel was satisfied with the instruction to the witness not to answer.

"Mr. Hall: All right.

"Mr. Thiess: Which we thought was more potent than getting an answer from the witness.

895 "Mr. Haight: Not to consume the time of the Court here, you see that we were right, Mr. Thiess,
788 or rather Mr. Hall was, because I wasn't there.

"The Court: All right, proceed.

(Counsel continues reading:)

"'Mr. Hall: The same objection and the same instruction to the witness until advised by the Court.

'Mr. Thiess: Q. In that statement what do you mean by "substantially all the charging stock is at all times during such primary heating retained in liquid form and cracking thereof substantially avoided"?

'Mr. Hall: The same objection, and the same instruction to the witness.

'Mr. Thiess: Q. I refer you again to page 2 of the same patent, lines 32 to 40, and ask you whether the word "vaporization" as there used means vapor formation?

'Mr. Hall: The same objection, and the same instruction to the witness.

'Mr. Thiess: Q. I refer you again to this patent—'

"Mr. Haight: Just a moment. I understand that your Honor ruled both of those question out.

"The Court: Yes.

(Counsel continues reading:)

"'Q. I refer you again to this patent at page 4,
789 line 50, to the statement:

'"By thus primarily heating the charging stock we are enabled to most materially reduce the heat demand upon the heating element of the cracking system proper which, therefore, need not be greater than to supply the heat of the reaction, vaporization, refluxing and radiation losses, thereby eliminating excessive cracking of portions of the oil." Does the word "vaporization" as there used mean vapor formation?

'Mr. Hall: The same objection and the same instruction to the witness.'

"Mr. Haight: The same ruling?

"The Court: Same ruling.

896 "Mr. Thiess: What?

"The Court: The same ruling by the Court.

(Counsel continues reading:)

"'Mr. Thiess: Q. I refer you to patent No. 1,449,227, Defendants' Exhibit 554, page 1, line 88, which reads:

'"this additional heat being sufficient to compensate

for the loss of heat due to vaporization from the vaporizing chamber, loss due to radiation, etc."

790 'Does the word "vaporization" there used mean vapor formation?

'Mr. Hall: The same objection and the same instruction to the witness.'

"The Court: Same ruling by the Court.

(Counsel continues reading:)

"'Mr. Thiess: Q. I refer you again to this patent, page 4, beginning at line 72, which reads as follows:

"'If, therefore, the temperature of the oil in the coil be allowed to rise materially beyond that of the bulk oil in the vaporizing chamber, it is evident that vaporization will occur in the coil unless provision is made to prevent this. This vaporization may be prevented by maintaining a certain predetermined pressure on the oil in the heating coil or heating zone in excess of that of the balance of the system."

'Does the word "'vaporization" as there used indicate or mean vapor formation?

'Mr. Hall: The same objection and the same instruction to the witness.'

"The Court: Same ruling by the Court.

(Counsel continues reading:)

791 "'Mr. Thiess: Q. I refer you to the statement in your patent No. 1,655,603, at page 1, line 35, which reads:

'"The partial pressure effect of the steam is to permit a continual vaporization of the oil at a temperature below its boiling point at the pressure employed."

'Does the word "vaporization" as there used mean vapor formation?

897 'Mr. Hall: The same objection and the same instruction to the witness.'

"The Court: The same ruling by the Court.

(Counsel continues reading:)

"'Mr. Thiess: Q. How was this vapor formation effect by the partial pressure effected?

'Mr. Hall: The same objection and the same instruction to the witness.'

"The Court: Same ruling.

(Counsel continues reading:)

"'Mr. Thiess: Q. I refer you again to page 1, line 69, of this patent to the following statement:

'"The vapors of the lower boiling point oils being commingled with those of the higher boiling point oils
792 assist the vaporization of such higher boiling point oils by their partial pressure effect on the oil undergoing treatment."

'Does the word "vaporization" as used therein indicate vapor formation?

'Mr. Hall: The same objection and the same instruction to the witness.'

"The Court: Same ruling by the Court.

(Counsel continues reading:)

"'Mr. Thiess: Q. Do you know of any instance, and can you refer me to such, in which you use the word "vaporization" to indicate or mean the liberation of vapors from liquid in a small heating tube such as the "B" tubes of the Dubbs 1,392,629 patent?

'Mr. Hall: The same objection and the same instruction to the witness.'

"The Court: Same ruling by the Court.

(Counsel continues reading:)

"'Mr. Thiess: Q. Under those circumstances what caused you to believe that the instructions in the Dubbs 1,392,629 patent in suit, calling for the heating of the oil in the heating tubes to a cracking heat without substantial vaporization indicated an operation in which the oil was to be heated without vapor lib-
898 eration in the "B" tubes rather than without
793 vapor formation in the "B" tubes, which latter definition is the one which you have used in your patents that I have referred to?

'Mr. Hall: The same objection and the same instruction to the witness.'

"The Court: Same ruling.

(Counsel continues reading:)

"'Mr. Thiess: Q. Your patent attorney, Mr. Lyon, understood that these processes were of the liquid phase type, for he refers to them as follows, in his letter, Plaintiff's Exhibit 539, page 2, the first paragraph, the second sentence:

'"These interferences particularly relate to maintaining a temperature and pressure relation that will hold the product in the liquid phase."

'That is true, is it not?

'Mr. Hall: The same objection and the same instruction to the witness.'

"Mr. Von Holst: I don't think that is at all subject to the same ruling that you made. That is a letter that they produced.

"Mr. Haight: Well, the letter speaks for itself.

"Mr. Von Holst: Mr. Thiess had a perfect right to cross-examine the witness on it.

"The Court: Yes, but the letter does speak for
794 itself.

"Mr. Thiess: Yes.

"Mr. Von Holst: But the letter speaks in a manner in which the witness had not been speaking.

"Mr. Thiess: Had not been speaking.

"The Court: Well, whether it does or not, if it does, why, it is here and does speak differently. Read your question.

(Counsel continues reading:)

"'Mr. Thiess: Q. Your patent attorney, Mr. Lyon, understood that these processes were of the liquid phase type, for he refers to them as follows, in his letter, Plaintiff's Exhibit 539, page 2, the first paragraph, the second sentence:

899 '"These interferences particularly relate to maintaining a temperature and pressure relation that will hold the product in the liquid phase."

'That is true, is it not?'

"The Court: Well, that doesn't add anything. If the letter does say it, it does.

"Mr. Von Holst: It was a preliminary question, your Honor.

"Mr. Thiess: What was the ruling there?

"The Court: I sustain the objection.

795 "Mr. Von Holst: Your Honor has in mind that that question was preliminary to the next question 576.

"The Court: Well, the next question may be all right. The testimony of the witness as to what was in the letter adds nothing to the letter itself.

"Mr. Thiess: Does the record show the same objection and the same instruction to the witness?

"Mr. Von Holst: Yes.

(Counsel continues reading:)

"'Mr. Thiess: Q. As a man skilled in the art is it not true that the word "vaporization" as used in the art means vapor formation?

'Mr. Hall: The same objection and the same instruction to the witness.'

"Mr. Haight: That is the same question, your Honor, that we put to Dr. Brown and that was ruled on.

"The Court: Yes, objection will be sustained.

"Mr. Von Holst: I beg your pardon. I wish to differ with Judge Haight. It is not the same question that was put to Mr. Brown.

"Mr. Haight: No, I think you are probably right.

"Mr. Von Holst: Yes.

"Mr. Haight: Mr. Brown was asked about the
796 patent in suit.

"Mr. Von Holst: The question to Mr. Brown was, 'Would it be proper to say that the process of the Dubbs patent was one in which the oil was heated but without substantial vaporization?'

900 "Mr. Haight: Yes, I will withdraw that. I think that is right.

"Mr. Hall: The only proposition is they are taking this fact witness and endeavoring to draw from him an opinion as to the meaning of this term in the art. Now, your Honor has said you can refer to dictionaries and what not to find out the meaning of these terms, and in the last analysis that is what you must decide anyway.

"The Court: Yes.

"Mr. Von Holst: Certainly we are entitled to show that a man skilled in the art used the word in its ordinary sense.

"Mr. Hall: If you call him, possibly, but you are not entitled to take our fact witness.

"The Court: I think you have gone beyond the bounds of proper cross examination. That question was not gone into on direct examination of this witness anyway as I recall it.

797 "Mr. Thiess: But it was, your Honor, in this sort of a way. He was asked about why he was interested in this Dubbs patent. He went to his patent attorney. He asked for advice. His patent attorney gave him advice. He brought in one letter. He didn't bring in a long report from the patent attorney. Apparently there was none available, but we haven't seen anything of that kind. Now, in the light of that he must have considered this patent, and what we are trying to ascertain is what was in his mind back in 1923 when

this license was taken out. I believe we are entitled to search into those facts to find out what happened.

"The Court: Well, he stated in his direct examination that he relied on the advice of his attorney, and I don't see that this is cross examination on that.

"Mr. Thiess: Well, but he must have known what his attorney told him.

"The Court: Yes.

"Mr. Thiess: As to that particular phrase.

"The Court: The objection will be sustained.

(Counsel continues reading):

"'Mr. Thiess: Q. In the sense in which you have
798 901 used the word "vaporization" in your patents referred to, would you say as a man skilled in the art that in your practice at the Standard Oil of California, where you heat the oil in a coil of restricted diameter and formed a substantial amount of vapors in said coil so that the hydrocarbon traveled through the coil as a foamy mass of mixed vapors and liquid, you were practicing a process where the oil was heated in that coil to a cracking temperature but without substantial vaporization?'

"Mr. Hall: That is the same thing exactly.

"The Court: It is the same thing.

"Mr. Von Holst: It is a question that is directed to identifying what they are trying to prove is the commercial process under the license with the process of the patent. How can whatever they did commercially, your Honor, have any bearing unless it was the process of the patent?

"Mr. Hall: Well, that is a conclusion your Honor will have to reach, whether it has any bearing or not.

"Mr. Von Holst: Yes, but we are entitled to find out what sort of process it was that they were produc-
799 ing commercially under this patent. Was it the process in which there was vapor formed in the coil or was it the process in which there was no substantial vapor formed in the coil?

"Mr. Hall: That is not what they are asking him.

"Mr. Von Holst: Yes, it is.

"Mr. Hall: That is just what your Honor told me I would have to do, show what the fact conditions were in the coil and you would reach your own conclusion as to whether there was substantial vaporization or not.

"Mr. Von Holst: That is not true, your Honor.

"The Court: Read it into the record under the rule. I am not quite certain. On a good many of these questions I am not quite certain what I should do. There is a good deal of discretion allowed in cross examination and sometimes departure from the matters concerning which the witness was questioned on direct examination. Frequently I am bothered to determine how far I should allow the cross examination to go, whether I should restrict it closely to the matters that were inquired into on direct examination. In this I am uncertain. I will let it be read in under the rule.

"Mr. Von Holst: There was no answer anyway.

800 902 "Mr. Haight: There is no answer.

"Mr. Von Holst: I will read what Mr. Hall said: 'The same objection and the same instruction to the witness.' What we were arguing was whether the question was proper or not.

"The Court: Oh, yes.

"Mr. Von Holst: Your Honor holds that it is not?

"The Court: Yes, I will so rule.

"Mr. Haight: What is your Honor's ruling?

"The Court: I am holding as before at this time."

In Plaintiff's Exhibit 538, and particularly the third paragraph thereof, our attorney, Frederick S. Lyon refers to his letter of July 3 (1924). I have not been able to locate that letter. I do not know what the contents of it were.

The improvement of patent No. 1,488,325, Exhibit 537, over the patent No. 1,392,629, Exhibit 500, is feeding the charging stock into the vapor column. I considered this feature very important at that time.

The Avon unit upon which we conducted these experimental runs has been recognized as a typical Dubbs. I have produced a book which contains runs conducted in this still at Avon. Those runs were commercial runs for our education and to prove out the statements that Mr. Halle had made and guar-

802 903 anteed. I do not recognize the names of the men that are signed on the run sheets as employees of the Standard Oil Company of California.

803 In the operation of our stills of the Dubbs type at the Standard Oil of California on our regular runs, on stills as exemplified in Exhibit 550 our principal

charge was gas oil but we undoubtedly also used fuel oil.

804 Drawing B-21601, DX 562, and A-21589, DX 563, illustrate the No. 1 unit furnace that we built. In DX 562, oil entered into the tube No. 114 and exited at the tube No. 1. The place where the oil entered was in the coolest part of the furnace.

805 The first runs on this No. 1 unit were made under our supervision, and the supervision of the Universal Oil Products Co.

808 I do not know that there was much knowledge of vapor phase operations, and that the time element was given any consideration. It was a very undeveloped art at that time, so we probably had no particular opinion on the fact that they were operated at high temperatures and short time factors.

810 Run No. 16 (DX 564) of the operation of the No. 1 still at the Standard Oil of California, is the only run that I could locate in which we operated that still without flashing.

811 DX 564 constitutes our method of keeping a record of temperatures within the tubes, fuel consumption, stack temperatures, flue temperatures and other details of operation of Run No. 16.

812 These cards show that the run of the Dubbs unit without flashing was from 7 a. m. on June 11 to 11 a. m. on June 15. It started on stream at 1 p. m. on June 11 and was taken off stream at 11 a. m. June 15, a total of approximately 87 hours. The charg-
904 ing stock used was gas oil. I do not know what
813 the level in the reaction chamber was. The character of the residuum, its gravity, varied after we got on stream. It went as low as 5.4 gravity, but after it was on uniform operation it ran about 8 gravity. It was a merchantable fuel oil. We sold much residuum of about that quality and gravity. I do not know the B. S. and W. of the residuum. That would not entirely determine its merchantability.

There is a big market for so-called Dubbs fuel oil here on the Pacific Coast which will permit up to 6 or
814 8 per cent flocculent carbon, so that this had commercial uses, if we wanted to sell it straight.

In Run No. 16, we used the apparatus as diagram-

matically illustrated in PX 550, excluding the part showing the flashing operation.

At the time I negotiated with Mr. Halle for the license agreement I was conversant in a general way with the litigation which was pending between the Universal Oil Products Company and the Standard
815 Oil of Indiana on the J. A. Dubbs patent No. 1,123,502.

I recommended to the officers of my company to negotiate with Universal Oil Products Company and to accept the terms of the 1931 contract entirely because of business consideration to save my company money. It was purely based on saving money and the basis of what we anticipated saving in royalties was made up by projecting our operations, but whether we were increasing or not increasing our capacity the question of getting what we had in the form of a paid-up license and saving money would have been the deciding influence in any event. It was all based on what we were going to spend and what we thought
905 we were going to get it for.

816 This flashing system which has been referred to, and which is shown in PX 550 was developed prior to the time that we entered into our original agreement with the Universal Oil Products Company. We started very soon to use this flash system on No. 1 Dubbs unit.

817 Increased yield was the advantage of this flashing system. The use of flashing affected our residuum
818 in that it lowered the gravity. On the general output of coke I do not think the flashing system had any effect.

906 Run No. 41 (DX 565) is typical of our so-called flashing operation as of that date. We are operating this flashing system in substantially the same way today. DX 565 constitutes the record of Run No. 41.
820 This run started 3:15 p. m. September 10 and went until 2:15 a. m. on September 20, 1926. It came on stream at 10 p. m. September 10, and went off stream
821 at 2:15 September 20. The cards do not give the level of the oil in the reaction chamber. I think it would have been the same as the level in the operation as exemplified by Run No. 16. The charge in this Run 41 was gas oil.

The regular operating schedule of 600 hours was

subsequent to this time because these runs are not for that length of time. These 600-hour runs were all undoubtedly made on the flashing operation.

822 In the runs that we conducted on the flashing, as exemplified on PX 550, we used a horizontal reaction chamber. Thereafter we used vertical reaction chambers entirely.

823 "Q. In this flashing operation you reduced the pressure from your operating pressure to a lower pressure so as to cause the formation of vapors in your tar expansion tower: Is that correct?

"A. So as to distill by the residual heat the lighter fractions contained in the cracked residuum.

"Q. In other words, you would get vapors formed in there that would go off as a result of the residual heat: Is that right?

"A. Vaporization would take place as a result of releasing the pressure and realizing the residual heat."

907 The temperature drop which occurred in the tar expansion chamber was due to vaporization of the liquid that was expanded in those operations. This drop in temperature was undoubtedly due to the fact that the heat was consumed in the latent heat of vaporization. As far as I know, no cracking occurred in this tar expansion chamber.

At the time of negotiating our license under the Universal Oil Products Co's. patents, we were advised and proved to our satisfaction that the Dubbs process would produce good yields of commercial gasoline. We discussed and proved to our satisfaction that the deposition of carbon in the tubes was a minimum. The records will show that in the operation at Martinez which we witnessed, there was considerable coke produced. At the same time, nobody advised us of anything relative to making commercial residuum containing less than 1 per cent of B. S. in this Dubbs unit, but we were permitted to see it and draw our own conclusions.

The flashing operation which was introduced in the operation of the Dubbs process by the Standard Oil of California was generally adopted throughout the country during that period, just following our 1925 demonstration of it.

I do not recall of even making one run of the so-called non-residuum Dubbs operation, although we might have made one. We were not interested in the non-residuum operation because we had a market for fuel oil and thought that was the most economical overall operation.

908 MACAULEY CARTER, Lake Forest, Illinois:

Direct Examination by Mr. Haight.

839 I have been assistant secretary of the Universal Oil Products Company since 1931 and I have custody of the company records.

PX 569 is an agreement between the Universal Oil Products Company and the Mid-Continent Petroleum 841 Corporation dated January 1st, 1936. PX 570 is a supplemental agreement, and PX 571 is a letter of cancellation of the license contract written by the Mid-Continent Corporation by Mr. France dated August 31, 1938.

Abstract of PX 569: Under date of January 1, 1936 Universal licenses Mid-Continent to operate several cracking units at Tulsa, Oklahoma under more than 400 Universal patents (including the patents in suit.) Mid-Continent agrees to pay royalties on the throughput at specified rates and with specified minimum royalties. Universal agrees to hold Mid-Continent harmless against any charge of infringement made by others on account of Mid-Continent's operations under the license.

Abstract of PX 570: This is an agreement dated January 1, 1936 between (1) Mid-Continent, (2) the plaintiff, Universal Oil Products Company, a Delaware corporation, and (3) Universal Oil Products Company, a South Dakota corporation. It recites pending patent litigation between Universal (South Dakota) and Mid-Continent. Universal (South Dakota) and Universal (Delaware) release Mid-Continent from all claims of past infringement. Universal (Delaware) and Mid-Continent agree to enter into a license agreement (PX 569, above) which shall be cancellable at any time after thirty days, provided Mid-Continent is not then in default and shall have made full payment of

the $1,000,000 recited below. After such a cancellation Universal (Delaware) and Universal (South Dakota) shall have the right to assert their cracking patents against Mid-Continent for its subsequent cracking operations.

909 Mid-Continent agrees to pay Universal (Delaware) in addition to its obligations under PX 569, the sum of One Million dollars, one-fourth of which is to be paid on the execution of PX 569, and the remainder in specified installments.

Mid-Continent releases Universal (South Dakota) and Universal (Delaware) as well as their licensees, from any claim of infringement under Mid-Continent's cracking patents subject to specified limitations. Universal (Delaware) is given the right to sue, for its own benefit, for infringement of any of Mid-Continent's cracking patent rights, subject to specified limitations.

Provision is made for the termination of the litigation pending between Universal (South Dakota) and Mid-Continent.

Abstract of PX 571: Under date of August 31, 1938, Mid-Continent, pursuant to the right of cancellation given by PX 570, gives notice to Universal (the plaintiff) of its cancellation of the license agreement, PX 569, effective as of October 4, 1938.*

843 Change in Royalty Rates by Universal: The first change in royalty rates was made in 1934. The royalty
844 was then reduced from fifteen to ten cents a barrel throughput. The reason for this change was that the competitive situation in 1934 caused Universal to believe that it was necessary to reduce its royalties in order to maintain and increase business.

The next change was made effective October 1st, 1938. At this time Universal recognized that with the expiration of the Dubbs patent 1,392,629, it might be
845 faced with the situation that unless the royalties were reduced some of Universal's licensees might be lost. This Dubbs patent expired in October 1938.

910 *Cross-Examination by Mr. Thiess.*

846 I was in sales work with Universal prior to the time that I became assistant secretary. I contacted our

* October 4, 1938 is the date of expiration of the Dubbs patent in suit, No. 1,392,629.

licensees and, of course, prospects for the process. I do not recall that I ever contacted the Mid-Continent Petroleum Company with respect to this license that we have introduced. The negotiations were carried
847 out largely by Mr. Halle in New York. We had a suit against the Mid-Continent Petroleum Corporation prior to this license. We may have been suing on other patents besides the 629 patent that I have referred to. I don't know of my own knowledge but I have heard that Mid-Continent took a license from the Gasoline Products Company at the time that they can-
848 celled in accordance with PX 571. Universal sued the Mid-Continent after that. That suit was also discontinued. I do not know why it was discontinued.

On October the 1st, 1938 we reduced our license fee from 10 to 5 cents. In December 1937 Universal had obtained a license from The Texas Company to license under the patents owned by the so-called patent group.
849 The Gasoline Products Company, The Texas Company, and so forth. I could not say that this license that was obtained under these patents owned by The Texas, Gasoline Products, etc., had any influence in the discontinuance of the second suit against the Mid-Continent Company.

911 The following exhibits, all of which were formerly exhibits in the Root case, were offered in evidence:

851 PX 572. Statement of royalties received year by year from the Shell group and Standard Oil of California from 1922 to December 31, 1930.

Abstract: The grand total of royalties from these two licensees, up to December 31, 1930, was $33,576,496.40.

852 PX 573. Statement of the royalties received from licensees other than Shell and the Standard Oil Company of California group from 1922 to December 31, 1930.

Abstract: Thirty-seven domestic and eleven foreign licensees are listed. Royalty payments up to December 31, 1930 aggregated $16,430,492.04.

PX 574: Statement of the monies credited to the Shell Company and the Standard Oil Company of California in the amount of one quarter of the royalties for the purchase by Universal of patents of those two companies.

Abstract: The amount credited to the Shell Company was $2,942,077.65 and to the Standard Company $591,026.51. Total: $3,533,104.16.

853 PX 575: Stipulation entered into in the Root case in lieu of the various license agreements.

Abstract: This exhibit contains a list of the various licenses granted by Universal Oil Products Company prior to December 31, 1929. The various patents and applications under which each license was granted are listed.

912 BERNARD G. LENSKE, Oak Park, Illinois:

Direct Examination by Mr. Haight.

853 I am comptroller of the Universal Oil Products Company and I have control of the journal of the Universal Oil Products Company. Journal Voucher No. 1019, PX 576, is a record of the receipt of $10,000,000 in January 1931 from the Shell Union Oil Corporation and the Standard Oil Company of California. Note: The purpose of this voucher is to show that $10,000,000 was paid by the Shell and Standard of California Companies for a paid up license. $3,000,000 was paid by Standard (Hanna, R. 648) so the remaining $7,000,000 was paid by the Shell Company.

913 *Cross-Examination by Mr. Theiss.*

855 PX 576 indicates that six million dollars in notes
856 were received. According to this statement we got four million in cash and six million in notes, but that was a transaction between the former stockholders of Universal and the companies who purchased the stock at the time the deal was made on January 6, 1931. I cannot say what became of the notes. Those notes did
857 not go to Universal. Ostensibly the notes and cash went to the company. But I assume instead of that the notes went directly to the stockholders as a dividend. I do not know that some of those notes went to others besides stockholders.

The $253,000 item represents interest on the ten million dollars at the rate of 5 per cent for six months, covering the period from July 1, 1930 to December 31,

858 1930, and the amount would be $250,000. That was treated the same as the $10,000,000 to which we referred and was handled by Mr. Halle and Mr. Dunham, who were president and vice-president respectively at that time and I don't know how it was distributed.

The next item, 61, is a credit to the surplus account of the $250,000. The surplus is the account to which the earnings from the corporation are credited at the end of the year. When books are closed, the profit accounts are closed into a surplus account, and this trans-
859 action reflects the record of the $250,000 cash paid as interest on the $10,000,000 deal from July 1 to December 31, 1930. That again was disbursed in such
859 914 a way that I don't know who got the money.

The next item, "Profit and loss 1931" refers to the interest on the same $10,000,000 but covering the six-day period from January 1, 1931, to January 6, 1931, which was the effective date of the deal.

The next item, "To record interest on cash and notes received for royalty grants fully paid and advanced for the period July 1st to December 31, 1930"; is an explanation for the debits and credits as they appear in this journal, and covers the very same matter which I have just explained.

This sheet does not purport to show the rebates granted to the Shell and California companies on account of the purchase of their patents.

915 L. C. HUFF, Winnetka, Illinois:

Direct Examination by Mr. Thomas.

861 Qualifications: I am employed in the engineering department of the Universal Oil Products Company and have been associated with this company since May, 1921. I served as chief engineer for about four-
862 teen years in charge of designing and constructing cracking units. My first assignment in May 1921
863 was to obtain operating experience and to become familiar with the construction of the Dubbs Unit No. 1 of the Roxana Refinery at Wood River, Illinois. This still was designed under the direction of Robert T. Pollock, who was chief engineer of the Universal
864 Oil Products prior to May 1921. After my arrival

at Roxana I modified this still by redesigning certain oil lines in order to provide for expansion and contraction, and made other changes which improved its operation. These modifications were made as soon as the necessary materials were obtained.

865 Dubbs Roxana Unit No. 1: PX 522 comprises the drawings of the original Dubbs No. 1 unit constructed at the Roxana Refining Company. PX 577 is a simplified diagrammatic flow sheet of the No. 1 Dubbs unit prepared under my direction. PX 578 is a mounted enlargement of this flow sheet.

867 The equipment shown on PX 577 comprised three major items: (1) a furnace which contained four banks of tubes marked F; (2) two sets of vaporizing chambers marked H which were mounted immediately over the furnace but in a separate compartment; and

868 (3) a dephlegmator, marked C, which was mounted some distance above the rest of the apparatus. The dottel lines shown adjacent to the coils are the out-

916 lines of the walls which separated the combusion chambers from the coils.

The ray oil to be charged to the process was received from storage by a pump A and was charged through a line B into the top of a dephlegmator C wherein it flowed downward over pans countercurrent to the rising vapors therein. The arrangement of these pans is shown in the cross section of the dephlegmator C. The raw oil as it entered the

869 dephlegmator partially condensed some of the vapors rising therein, and the condensate from these vapors, called "reflux", gravitated to the bottom of the dephlegmater in admixture with the raw oil, and passed into the reflux leg D, and then through the combined feed line E into the inlet of the four-inch heating coils F.

The four-inch heating coils were identical in construction, but each was independent and located in a different furnace compartment. Each coil consisted of twelve four-inch outside diameter tubes twenty feet long. The four coils were independent, but the tubes in each coil were connected in series by return bends.

The heated oil from two of the coils joined into the transfer line G and passed to one set of vaporizing coils H. The heated oil from the other two coils joined

a similar transfer line G and entered into the other set H of three vaporizing coils.

870 The heated oil and generated vapors entered the chamber No. 1 of the vaporizing tubes H, flowed to the far end of that chamber, crossed over into the No. 2 chamber, and then flowed to the far end of that chamber. Vapors were taken off overhead through a vapor line K and entered the dephlegmator C where-

in they were subjected to partial condensation by

917 the incoming raw oil, as previously described.

The unvaporized liquid remaining in the vaporizing chamber H crossed over and flowed into the chamber marked 3 and then to the opposite end of that chamber where it was continuously withdrawn through a line W and sent through a cooler to storage. The uncondensed vapors from the dephlegmator C passed overhead through a line L into the final vertical condenser M and then were passed into a receiver N. In the receiver N the separation of the uncondensable gas and the condensate took place.

871 Originally a portion of the combined feed from the reflux leg was pumped to the top of the dephlegmator in regulated quantities for the purpose of controlling the temperature at the top of the dephlegmator, but at a later time pressure distillate was recirculated from the receiver N into the dephlegmator C by pump S through line T.

The remaining distillate from the receiver N was withdrawn from the bottom through a valve P and sent to storage. The pressure distillate contained the gasoline, which was the prime object of the cracking operation, and the gasoline was recovered by distillation. The uncondensable gas was withdrawn from the top of the distillate receiver N through the valve R.

A pressure of 135 pounds was usually maintained on the apparatus and was controlled by regulation of the outflow of gas through the valve R.

The reflux that collected in the reflux leg D in admixture with the raw oil was returned by gravity

through the combined feed line E to the heating

918 coils. The dephlegmator C was set at such an

elevation that the head of the liquid that built up in the reflux leg D was sufficient to overcome the friction in the tubes and force the oil through the

heating coils. The dephlegmator was about 26 feet high with a net head of about 12 feet.

Throughout the operation of the No. 1 unit, the residuum withdrawn from each set of vaporizing
874 chambers marked H through residuum connections marked W was not returned to the heating coils.

The oil received its entire cracking heat in the four banks of heating coils marked F.

The vaporizing chambers were located in a separate compartment mounted immediately over the furnace. This compartment was unheated but was heavily insulated to prevent radiation losses.

The charging stock for the unit was gas oil. During normal on-stream operation the approximate temperature of the combined feed that accumulated in the reflux leg D was between 700 and 760° F.

876 The cracking coils were four inches outside diameter and twenty feet long. There were twelve tubes in each bank and each independent bank was about 240 feet long. The vaporizing chambers consisted of three 16-inch outside diameter pipes approximately twenty feet long giving a total length of about sixty feet. The dephlegmator was approximately three feet six inches in diameter by twenty-one feet high.

During the normal on-stream operation of the unit the temperature of the hydrocarbons leaving the
919 heating coils, called the transfer temperature, was within the range of 840 to 865° F., but on the earlier runs of this unit the transfer temperature was
878 on the order of 800° because of the newness of the
920 unit. The pressure was maintained at approximately 135 pounds.

It was the usual practice to start out a run with the liquid level approximately one-third the way up the diameter of the vaporizing chambers. This level was allowed to build up until it reached the halfway point towards the end of the run. The indication of the liquid level was obtained by means of liquid level
879 lines which are indicated on vaporizing chamber #2.

The rated capacity of the unit was between 200 and 250 barrels per day of charging stock. Ten regular runs were made, and they were all complete with the exeeption of two runs, one of which was shut down because a rag was found at the inlet of one of the banks of heating tubes, and the other of which was

terminated while coming on stream due to a leaky gasket. In all there were eight complete runs.

A typical run made on this unit, made during the early part of August, 1921, on a 35° Be. gravity gas
880 oil at 135 pounds pressure, lasted fourteen days on stream. The through-put was about 235 barrels per day, and the transfer temperature was between 790 and 820° F. The yield of Navy Specification gasoline was approximately 28 percent by volume based on the raw oil charge. About 40 percent by volume of residue based on the charge was withdrawn from the vaporizing chambers, and this residue had a gravity of about 25 to 29° A. P. I.

The reflux condensate from the dephlegmator, in admixture with the raw oil charge, was returned to the heating coils. The unvaporized liquid in the vapor-
885 izing chambers was withdrawn and was not returned to the cracking tubes. In general, this was typical of all the runs made on the unit in that the reflux from the dephlegmator in admixture with the raw oil was always returned to the heating coils and
921 the residue from the vaporizing chambers was withdrawn from the system.

Only ten runs were made on the unit because when the eleventh run was attempted an explosion occurred, which wrecked the apparatus. At that time I was in Chicago, but immediately upon hearing of this explosion I was sent to Wood River to investigate and find out what had caused it. I reached the conclusion that the reason for the explosion was that in attempting to make a short cleanout, sufficient time
886 had not been allowed for the heating coils to cool off. In those days it was customary to give the apparatus an air test to make sure that there were no leaky joints. The air was being withdrawn from the system at the time when the raw oil was charged to the unit. The mixture of oil and air entering the heating tubes reached the ignition point and the explosion which wrecked the unit occurred.

Dubbs Roxana Unit No. 1-A: Following the explosion of the No. 1 unit, another unit called No. 1-A was installed on the same site. The design and construction of this unit was under my supervision. The construction work began in February, 1922 and it was placed in operation in June 1922.

887 PX 579 A, B and C comprises drawings 621-F, 690-F and 691-F, which are the drawings of unit 1-A.

PX 523 is a simplified diagrammatic flow sheet showing the construction and operation of Unit No. 1-A,
889 prepared under my direction from the detailed drawings. In general, this plant was of the same design as Unit No. 1, with the exception that the furnace, instead of having four coils, had only a single set of coils. The tubes were four inches in outside diameter and thirty feet long. There were thirty-three tubes in the coil, giving a total length of about 990 linear feet.

922 The vaporizing or expansion chamber was situated alongside the furnace in a separate compartment that was insulated but unheated. The rest of the apparatus was substantially the same as the No. 1 unit.

In the No. 1-A unit the oil was received by the raw
890 oil pump and charged to the top of the dephlegmator wherein it partially condensed the rising vapors. The reflux, in admixture with the raw oil, gravitated down the reflux leg through the combined feed line, and through the coil. The heated oil and generated vapors were discharged from the coil into the expansion chamber. The vapors were withdrawn from the other end of this chamber and passed to the dephlegmator, wherein they were subjected to partial condensation.

The vapors not condensed in the dephlegmator passed overhead through a coil condenser and the condensate (pressure distillate) collected in the final receiver and was continually withdrawn to storage. Regulated quantities of pressure distillate were with-
891 drawn from this receiver and returned to the top of the dephlegmator to control the temperature therein.

In some of the runs, it was found advisable, instead of feeding the raw oil overhead into the dephlegmator, to feed it direct to the tubes along with the reflux. In other cases, we practiced what was called a "split feed"; that is, part of the oil was charged overhead to dephlegmator and part was fed direct to the coils. This was all gauged by controlling the temperature of the vapors at the top of the dephlegmator.

The means employed in this plant to insure the return of the reflux to and through the crackling coils was the elevation of the dephlegmator, which

was at a sufficient height above the rest of the equipment to accumulate a head of liquid in the re-
923 flux leg which forced the combined feed through the heating coils.

The oil received its entire cracking heat in the furnace cracking coil. The normal liquid level maintained in the expansion chamber was at about the one-third point in the beginning of the run and as the run progressed the level was built up until it reached the halfway point or a little above.

The unvaporized liquid in the expansion chamber was continuously withdrawn through the residue lines
892 and sent through coolers to storage. It was not returned to the cracking coil.

This unit was designed for an operating pressure of 200 pounds and the pressure generally used was from 170 to 190 pounds on gas oil and 110 to 120 pounds on fuel oil. The pressure was maintained throughout the system.

Operation of Unit 1-A on Gas Oil: In a typical gas oil run the transfer temperature was within the range of 840 to 880° F. During the later operations, temperatures of a higher order, in the neighborhood of 900° and above, were used. I was present at this plant shortly after the higher temperatures were used and I had available to me all the records.

I recall a run made on 35° Be. gravity gas oil at 170 pounds, which lasted about 8¼ days. The capacity was approximately 300 barrels per day. The transfer temperature was within the range of 840 to 870° F. The yield of Navy Specification gasoline by volume based on the charge was about 37 percent.

893 Operation of Unit 1-A on Fuel Oil: On fuel oil the transfer temperature in the beginning was within the same range as that given for gas oil. The pressure was usually between 110 and 120 pounds. On later runs the transfer temperatures were also increased to the order of 900° F.

924 I recall a run made on about 24° gravity fuel oil at 119 pounds pressure which lasted about two and one-third days. The capacity was about 490 barrels a day. The transfer temperature was within the same range as that given for the gas oil. The yield of Navy Specification gasoline was 35 per cent based on the raw oil charge.

The reason the fuel oil run was short as compared to the gas oil run was that the expansion chamber accumulated carbon during these runs and on the gas oil there was not as much carbon formed as on the fuel oil. Consequently on fuel oil, which contained more carbon forming material than gas oil, the runs were much shorter. That accounts for the difference in the length of these runs.

897 The accumulation of carbon in the expansion drum determined the length of the run. I do not recall any normal run on either Dubbs Unit No. 1 or No. 1-A that was shut down because of carbon in the tubes.

In all the operations on this unit with which I am familiar, the reflux condensate was returned in admixture with the charging stock to the cracking coils, and the liquid residue that remained in the expansion chamber was withdrawn to storage and was not returned to the cracking coil.

898 The No. 1-A Unit was accepted by Roxana Company after the test runs.

Dubbs Roxana Unit No. 2: The Roxanna Company installed another unit, called Dubbs Unit No. 2, the erection of which was started in April 1922 and it was placed in operation during November 1922. The design and erection of this unit was under my immediate supervision.

925 The following exhibits are blueprints from the original drawings of this No. 2 Unit: #756F, PX 580; #862F, PX 580-A; #755F, PX 580-B; #933A, PX 580-C; #867F, PX 580-D; #866F, PX 580-E; #683F, PX 580-F.

903 PX 524 is a flow diagram which was prepared in 1923, sometime after this unit had been placed in operation to illustrate its construction and operation.

The design of unit No. 2 was almost identical to that of Unit No. 1-A, with the following exceptions: (1) It had one additional tube in the heating coil; that is thirty-four 4-inch tubes 4" outside diameter and thirty feet long and (2) it had a vertical reaction chamber 10 feet in diameter by 10 feet high. The reaction chamber was set alongside of the furnace in an insulated housing.

The process carried out in Unit No. 2 was identical with that carried out in Unit No. 1-A.

In the earlier operations of Unit No. 2, the transfer temperature usually range between 860 and 890°. The temperatures were increased shortly after the unit was built to the order of 900° and above. This applies to both gas oil and fuel oil charging stocks. In typical
905 representative operations the temperature range of the combined feed that accumulated in the lower part of the dephlegmator leg in the overhead feed operation was between 700 and 750°. On "direct feed" it was somewhere between 500 and 600° F.

926 The pressures employed on the No. 2 Unit were between 140 and 170 pounds when cracking gas oil and between 100 and 150 pounds for fuel oil. The type of charging stock and the yield desired determined the operating pressure.

In the normal on stream operations of the No. 2 unit at Roxana the reflux condensate, in admixture with the raw oil was returned to the cracking coils, and the unvaporized liquid that remained in the reaction chamber was withdrawn from the system and was not returned to the cracking tubes.

I was in charge of the first run made on the No. 2 unit. It was made on a 35° Be. gas oil at a pressure of 145 pounds, and the unit remained onstream for approximately six days. The through-put was approximately 300 barrels a day. The transfer temperature was about 860° F. The temperature of the combined
907 feed was between 720 and 750° F. The yield of Navy Specification gasoline was 38 per cent based on the raw oil. About ten percent of residue was produced during the run. It was a salable fuel oil.

The second run on the unit was made on fuel oil. This run was made at 100 pounds pressure and the unit remained on stream for seven days. The throughput was approximately 450 barrels a day. The transfer temperature was about 880°. The yield of gasoline was about 31 percent of Navy Specification by volume based on the raw oil. About 40 percent of residue was
908 produced and the residue had a gravity of about 16° Be. After the second run made on this unit, fuel oil was generally charged.

Dubbs Standard 500 Barrel Units: The next unit explained in the industry by the Universal Oil Products Company was the so-called "500 barrel standard

plant". That plant is fairly typified by the flow dia-
927 gram, PX 524, illustrating the No. 2 Roxana Unit.

The standard 500 barrel unit was designed for a nominal capacity of 500 barrels of charging stock. This capacity was selected mainly because it was rather high in those days and we thought it would serve the needs of most of the refineries and because we thought by standardizing on a set design we would be able to obtain better delivery on materials, better prices, etc., and as a result give our licensees a less expensive unit.

909 Construction work on the first standard 500-barrel units was started in the summer of 1922 and the first ones were operated in February 1923.

910 In November 1922, while the Roxana No. 2 Unit was in operation, the Roxana Company ordered four of these standard 500 barrel plants and construction work was started immediately. During the construction of these four units, Roxana ordered two additional units and construction work on these latter units was started in December. This made a total of six of the standard 500-barrel units ordered by Roxana in 1922. The first of them began operations, as I recall, in June, 1923, and the last was placed in operation in January, 1924.

Model of Standard 500 Barrel Unit: PX 581 shows two of the standard 500-barrel plants. The furnace of each plant contained fifty 4-inch tubes 30 feet long located in a box-like structure. The total length of the coils was approximately 1500 feet. Adjoining the tube bank was the combustion chamber, containing fuel oil burners located at each end. The hot gases from the combustion chamber passed overhead and down-
912 ward through the bank of tubes to the flue leading to the stack. A vertical reaction chamber was set alongside the furnace. The dephlegmator was mounted on a high steel supporting structure.

928 The oil to be processed was charged to the top of the dephlegmator by means of pumps located inside the receiver house. The charging oil, in admixture with the reflux condensate, passed down the reflux leg and entered the lowermost heating coil.

Leaving the heater, the oil and generated vapors passed through the transfer line and discharged into the top of the vertical reaction chamber. Here the separation of the vapors from the unvaporized liquid

took place. The vapors passed upwards through the
913 vapor line, entered the bottom of the dephlegmator and were partially condensed by the incoming raw oil and by the recirculation of pressure distillate withdrawn from the final receiver and returned to the top of the dephlegmator.

The remaining vapors passed from the top of the dephlegmator and then through the condenser coil located on top of the receiver house. The condensate from this coil condenser flowed into the pressure distillate receiver which was located at the back of the receiver house.

In the pressure distillate receiver the separation of the uncondensable gas from the pressure distillate took place. The pressure distillate contained the gasoline which was the prime object of the cracking operation. It was withdrawn from this receiver and sent to storage.

The uncondensable gas was withdrawn from the top of the receiver and sent to the refinery fuel storage.

The control valves were located inside of the receiver house.

The unvaporized portion of the oil that remained in
914 the reaction chamber was withdrawn through the residue lines located on the side of the vessel, and
929 passed through a cooler and then sent to storage.

There were three residue lines located on the side of the chamber. It was the practice to start the run using the bottom residue connection. As the coke level built up, the residue line became successively clogged with coke and it was usually necessary to withdraw residue from the next higher line. In some cases, however, complete runs were made wherein the chamber filled almost completely with coke, and yet the bottom residue line was used.

915 In a normal operation the coke level in the reaction chamber built up within about three or four feet of the top manhole, but in many cases the coke level was allowed to build up higher. This caused carbonaceous material to be carried up into the vapor line and sometimes into the dephlegmator and reflux leg, but aside from that it did not interfere with the operation of the unit.

In the early standard 500-barrel units various sized chambers were used. In some of the units chambers

ten feet in diameter by ten feet high were used. In others two chambers were installed with the idea of using only one chamber at a time. The No. 2 unit previously referred to had two small chambers, the purpose being to operate one chamber until it filled with coke and then during the cleanout to switch the trans-
916 fer line and the vapor line over to the other chamber. In this case we had only to clean the tubes and then start the run and the coke was cleaned from the first mentioned chamber at the operator's convenience while the run was in progress.

On later units the reaction chambers were increased in size to ten feet in diameter by fifteen feet high, and sometimes two of these vessels were used. The size
930 was increased to obtain longer runs, particularly on heavy stocks, and for that reason we increased the size to 10 x 30 foot vessels, and some of the plants had two 10 x 30 foot vessels. Later 10 x 40 foot chambers were installed and on some of the larger plants of about 1000 barrels capacity, two 10 x 40 foot chambers were used.

Irrespective of the size of the chambers in all of the standard 500-barrel units, the reflux condensate, in admixture with the raw oil, entered the heating or cracking coils and the liquid residue from the reaction chamber was withdrawn through the cooler to storage with the exception that in some of these operations we practiced a "non-residuum" operation. A non-residuum operation is one in which no residuum was withdrawn from the chamber and the residuum collects in the chamber and is permitted to go to coke.

The raw oil feed was fed in many instances to the top of the dephlegmator to control the temperature therein. In some cases the raw oil was fed directly to the tubes, at other times it was split, part going overhead and part direct. The reason for this was that the temperature of the vapors entering the dephlegmator was between 775 and 820° F. and the vapors coming from the top of the dephlegmator were between 540 and 560° F. This difference in temperature had
918 to be brought about by doing a certain amount of cooling in the top of the dephlegmator. The raw oil accomplished part of this cooling. The other part was accomplished by recirculating regulated portions of the pressure distillate.

The recirculation of regulated portions of pressure distillate was obtained by withdrawing a portion of the distillate from the receiver and charging the distillate in the form of a spray into the dephlegmator,
931 wherein it was vaporized and immediately passed overhead as vapors. This partially condensed the vapors therein and the condensed portion or reflux condensate passed down to the reflux leg and returned to the heating coils.

919 In either the direct feed or the split feed operation the charging stock which went direct to the coils entered the combined feed line just before it entered the heating coil wherein the raw oil was preheated at the expense of the temperature of the reflux.

The installation of the standard 500-barrel units was begun in 1922 and continued throughout the years until 1929. During the latter part of this period twelve additional tubes had been added to the heater and many of the units were equipped with hot oil pumps but with these exceptions they were substantially the same, except as to size, as the 500-barrel units previously de-
920 scribed. Approximately one hundred of these standard 500-barrel plants with the elevated dephlegmators were constructed and placed in operation as "gravity feed" plants. The gravity feed was obtained by the long hydrostatic leg shown in the model, PX 581, and was the means for forcing the combined feed through the coils.

921 The charging stocks usually charged to the standard 500 barrel units were gas oil, fuel oil, and topped crude. In a typical operation on gas oil charging stock the range of pressure was between 150 and 190 pounds.
922 The transfer temperature was between 860 and 890° F. in the earlier runs. Later the transfer temperatures were increased to the order of 900° F.

Referring to the sheets which are summaries of the Roxana operation at Wood River on Units 1-A and 2, on Run 26 on Unit 1-A made December 1922 the average transfer temperature for the run was 898° F.
923 932 This run was made on fuel oil. On a similar run made on Unit 1-A, Run 38, made in February 1923 on fuel oil, the average transfer temperature for the run was 898° F. Run 43 made on Unit 1-A in March 1923 was also made on fuel oil, and the average transfer temperature for the run was 900° F. On Run 44

on Unit 1-A made in March 1923 on fuel oil, the transfer temperature was 900° F. On Run 10 on Unit No. 2 made on untreated kerosene distillate, a light gas oil and made in February 1923, the average transfer temperature was 904° F. On Run 9, Unit No. 2 made in January 1923 on untreated kerosene distillate, the average transfer temperature for the run was 906° F

924 I testified for the plaintiff in the Root litigation in 1933 in Delaware and I covered substantially the same subject matter that I have covered in my testimony in this case except that I did not bring in these higher transfer temperatures, but the description of the general operation was practically the same.

In the operation of the standard 500-barrel units on fuel oil the transfer temperature range was usually between 860 and 890° F. on the earlier runs, but this was shortly afterwards increased to the order of 900°

925 F. and above. The pressure was between 100 and 150 pounds. The approximate duration of the runs made on gas oil was between ten and twenty days, sometimes longer, with a yield of gasoline based on the charge of 40 to 50 percent and in many cases the yield exceeded 50 percent.

On fuel oil the runs usually lasted somewhere between four to ten days with a yield of gasoline based on the charge of 30 to 45 percent.

926 Extent of Use of Dubbs Units: PX 582 entitled "List of Standard Dubbs Cracking Units Constructed to June 1, 1926" is a tabulation that I had prepared from the records of the Universal Oil Products Company giving a list of the standard Dubbs cracking units constructed up to June 1st, 1926.

933 The caption "Licensees" indicates the licensees in the United States, and the caption "Foreign Countries" indicates the licensees in those countries.

The caption "Units Built for Gravity Feed" indicates the number of these units of these various licensees, which amounts to a total of 99 units.

Under the caption of "Units Built with High

927 Dephlegmators and Forced Feed" is given the number of units that were built with the same height of tower but to which hot oil pumps had been added. There are 52 such units, making a total of 151 units as of June 1, 1926. The units listed under the caption "Units Built for Gravity Feed", differed from the

units listed under the caption "Units Built with High Dephlegmators and Forced Feed" only in that the latter had hot oil pumps interposed in the combined feed line between the reflux leg and the heating coils. In all of the units listed under the caption "Units Built for Gravity Feed", the reflux, in admixture with the raw oil, was forced by gravity feed through the heating tubes.

928 I am familiar with the operations of the 500-barrel units at the Barnsdall Company which were installed in 1923. These units were the gravity feed type and they continued to operate as such until they were shut down in August, 1936, a period of thirteen years.

During this time these units processed 4,179,000 barrels of charging stock on which royalty was paid. That is the record for the gravity feed Dubbs clean circulation units. No reflux pump was used on these operations and no major changes were made in the units throughout this period. The Barnsdall
934 Company appears on PX 582 under the name of Waite-Phillips at Wichita, Kansas. The units at this refinery were originally installed for the Sterling Oil and Refining Company at Wichita, which was
929 later taken over by the Waite-Phillips and then by the Barnsdall Company. The Barnsdall Company was in the refining business for production of gasoline.

The Producers and Refiners Corporation of Parco, Wyoming, listed on PX 582, began operations in the latter part of 1923 or the early part of 1924, and they continued to operate under the gravity feed principle until the early part of 1927.

930 The Prudential Oil Corporation of Baltimore, Maryland began the operation of the four units listed under the heading "Gravity Feed" in 1923 and two units continued to operate as such until 1929.

931 As late as June 1, 1926 there were approximately 32 of these standard 500-barrel Dubbs units operating under the gravity feed principle in the various refineries of the licensees of the Universal Oil Products Company.

In 1929 the standard 500-barrel Dubbs units had been constructed in about 48 refineries in the United States and I have personally visited all of these refineries with the exception of six or seven. I was familiar with the plans used to construct those units

which I did not visit for they were prepared under my directions and the units were constructed under my supervision.

In all of these units the reflux condensate was returned to the heating tubes in admixture with the raw oil and the residuum in the reaction chamber on the "residuum" type of operation was always withdrawn
932 and not returned to the heating tubes.

In the "non-residuum" type of operation no
935 residuum was withdrawn from the reaction chamber. Otherwise it was exactly the same as the residuum type of operation. The residue was allowed to remain in the chamber until it cracked down to coke. As a result, the non-residuum runs were much shorter than the residuum runs because of the greater
933 production of coke. At the end of the run in the non-residuum operations any liquid residue or vapors that remained in the reaction chamber were blown down to a sump and the unit was steamed out and the coke then
934 removed. In all of the non-residuum operations none of the residue or coke was ever returned to the cracking coils. In all cases the reflux condensate was returned to the heating coil in admixture with the charging stock.

Most of the coke made in these units by the licensees was sold on the market as fuel. Some of it was processed and used for making carbon electrodes, etc.
935 Length of Runs of Dubbs Units: PX 583 is a summary sheet taken from my files on Run 90 made at the Roxana No. 2 unit at Arkansas City. To the best of my recollection, this run was made during December 1925 and January of 1926. This unit was the standard 500-barrel plant, but at that time had been equipped with a 10 x 30 reaction chamber and hot oil pump. The unit remained "on-stream" 36.7 days.
936 The "on-stream" period is the period over which the plant is producing pressure distillate, and does not include the remaining time for bringing the unit on stream and shutting it down.

The charging stock on this run was 34.8 Baume gravity gas oil and the yield of gasoline was 46.37 percent based on the raw oil. It was the residuum type of operation.
937 936 PX 584 consists of two summary sheets of a run made at Plant 2 of the Arkansas City Refining

Company's plant at Arkansas City, Kansas. These sheets cover an operation known as Run 4-B, made in March 1925. The unit remained on stream 28.62 days. The charging stock was gas oil of 34.4 Baume gravity. The run was made at 200 pounds pressure and the
938 yield of gasoline was 48.36 percent based on the raw oil charge. The transfer temperature was 830° F. The vapors to the dephlegmator were 789° F. and the combined feed temperature was 741° F.

The residuum oil withdrawn from the reaction chamber during this operation had a Baume gravity of 25.2 and the "percent solids by benzol" on a composite sample for the run was .8 percent by volume of the residue produced. The "benzol" test to determine percent solids was used by the refineries to indicate the amount of solid materials in the residue. The fuel oil produced in this run was a commercial fuel oil. The reflux in admixture with the raw oil was returned by gravity feed to the cracking coils.

939 PX 585 is a summary sheet of two runs made simultaneously on units 1 and 2 by the Waite-Phillips Company (later known as the Barnsdall Company) at Wichita, Kansas, in March 1925. Each unit remained on stream approximately 22-1/2 days. The capacity of each unit was approximately 410 barrels a day. The
941 charge was a gas oil of 35 Baume gravity and the pressure was between 150 and 160 pounds. The yield of gasoline based on the raw oil charge was 40.57 percent by volume. The residue produced was 31.25 percent based on the charge and had a Baume gravity of 24.5, although not indicated on the report I recall that the residue had a B. S. content of less than one
937 percent, and was a commercial or salable residue.

These units corresponded fairly well with the model PX 581 with the exception that the reaction chambers were 10 x 15 instead of 10 x 10.

942 Output of the Dubbs Unit: PX 586 is a schedule of
945 the number of licensees of Universal Oil Products Company from 1922 to December 1929 and indicates the number of units that were operated and the barrels and gallons through-put of those units during each successive year.

Amount of Investment in the Dubbs Units: PX 587 is a schedule showing the estimated cost of existing Dubbs cracking units and those under construction as

of December 31, 1929. At that time there were 241 units existing and under construction. The total estimated cost of those units was $44,434,000.

On the second page is given the number of Dubbs cracking units that were partly or completely dismantled as of that date. There were fifteen such units which, when added to the 241 units, made a total of 256 Dubbs units. The total estimated cost of these 256 Dubbs units was $45,939,000. This was just the
946 construction cost of the units proper.

938 *Cross-Examination by Mr. Theiss.*

946 I did not have any experience in oil cracking before I entered the employ of the Universal Oil Products Company in May, 1921. I did not have any technical training along engineering or chemical lines. My training has been mostly along practical lines.

My practical experience up to that time had been in the design and construction of steam power generating stations, boiler stations, piping systems, etc. My work with Universal Oil Products Company and my contacts with the oil industry have been confined largely to this Dubbs operation, but being interested in oil cracking I also acquired certain knowledge of other processes.

948 While I was at Roxana Company, there were two Cross units constructed there, and I knew of these units but I had nothing to do with their operation. There were some Cross units at the Indian Refining Company where I visited during the summer of 1921, but I did not have anything to do with the operating of those units.

I was at Roxana nearly all the time while runs were made on Dubbs Unit No. 1, familiarizing myself with the process, and was on shift duty during some of those runs to obtain experience.

949 I was present when No. 1A Dubbs unit at Roxana was put in operation and observed its operation carefully. I was thoroughly familiar with the operations of these three units, and I had charge of putting unit No. 2 in operation.

958 I was chief engineer of Universal Oil Products
959 939 Company from 1921 until about 1934 or 1935. Since that time I have been in the engineering

department in charge of special work. As the chief engineer I had something to do with the writing of bulletins that were sent out to the licensees with respect to the operation of these plants.

I recognize a bulletin, Form B-536, dated 1/15/26, as a bulletin issued by us as a precaution in the starting up of a plant, to operate the plant in such a way that the tubes wouldn't become dry and coke form
959 940 in them. I saw this bulletin when it was issued and O. K.'d it.

963 From the temperatures that existed I have always assumed that there was generated vapors in the heating tubes of the Dubbs units, and that the mixture in there was in a turbulent state. I never made any test to determine whether there was any vapor in those tubes.

965 In the operation of this Dubbs process, assuming you were taking off about 30 per cent of residue from the reaction chamber and you were maintaining the liquid level in the chamber constant, to maintain the withdrawal of about 30 per cent of residue a certain amount of vapor has to go up into that dephlegmator. Now, in my own opinion the expansion chamber itself does not generate all those vapors. Some of those vapors are generated back in the tubes. But I never
966 made any test to ascertain that. I had no way of knowing exactly what the state of that oil in the transfer line was. The deduction that I made was from my practical experience.

969 I don't think I can give you the reflux ratio that was used on the No. 1 plant exactly. That reflux ratio was a very hard thing to determine. At that time we thought, and I always considered that we had a reflux ratio of between three and five to one, that is, 3 to 5 parts of reflux to 1 of the charging stock. We tried to determine it but the only method we approached it by was by distillations of the pressure distillate, and so forth; but that was a very poor way. On No. 1-A and No. 2 we considered the reflux ratio about the same as on No. 1, and on the 500-barrel plant, it was
970 941 somewhere within that range. We never really knew accurately what our reflux ratio was.

971 We never had the end point of the reflux separate from the fresh feed, because on unit No. 1, we fed overhead, and what came down the reflux leg was com-

bined feed. I assume that this combined feed that was fed to the inlet of the four-inch tubes, was in a liquid condition when it entered the heating tubes of these Dubbs operations. It was condensed in the dephlegmator, and had fallen down the reflux leg; and it cer-
972 tainly wouldn't gravitate to the bottom of the leg unless it was in a liquid form.

Based on test data taken during run 3 of unit 1, over
973 a period of what appears to be 24 hours, the average temperature of the combined feed was 768 F. at 135 pounds with a gravity of 31.9 during that test period. I have no reason to believe that it was otherwise during the rest of the run.

974 The model PX 581 is an exact replica of the 500 barrel unit built for the Warner-Quinlan Company as far as I can determine.

975 In some cases we were able to feed all the feed charge into the dephlegmator on unit No. 1 and unit 1-A and in the standard 500-barrel units before we got our hot oil pump; that depended upon the capacity at which these units were operated.

Where they were operating at large capacities,
976 higher than the rated or normal capacity of the unit; we could not feed all overhead until we had the hot oil pumps. On certain units, we operated with all the raw oil fed overhead at capacities around 500
976 942 barrels. But we got into difficulty on most of the units when we did that and when they ran at higher capacities than 500 barrels. Whether we were able to feed into the dephlegmator exclusively when we ran at 500-barrel capacity and less is, of course, all
977 tied up with the reflux ratio and everything else, the type of charging stock. We thought the reflux ratio on these units varied considerably.

I don't recall that we had any difficulties when we fed all the raw oil overhead. In some cases if you fed it all over the top, it did too much cooling, and in those cases we split the feed and put part of it in at the top and part at the bottom. Why we cooled too much in some of these units and not in others again depends upon this reflux ratio, because that depended upon how much vapors you had going up through the vapor line to the dephlegmator. The heavier vapors all had to be condensed, and the only means we had of condensing those was by admitting raw oil overhead

and by trimming with a certain amount of pressure distillate.

978 In a large number of these standard 500-barrel plants usually on the higher capacities, we had to split the feed because we would get off-color pressure distillate.

979 Evidently our reflux and raw oil, our combined mixture, would build up to too high a level in the reflux leg and be carried off overhead and give us a contaminated pressure distillate. And in order to avoid that in some cases we resorted to split feed. We used split feed in many cases prior to the time we got a hot oil pump. Many of these plants were operated with split feed.

980 943 If we had a hot oil pump we could have fed all the raw oil to the dephlegmator if we had desired to do so. We first installed hot oil pumps on two units of the first battery of four standard 500-barrel units that were installed at the Moore Refining Company at Arkansas City. The two gravity feed units went into operation in February, 1923, and the two units with hot oil pumps followed in operation about April or May of 1923.

That was a lobe type of pump, made by the Connersville Blower Company, and used at that time by the

981 Sinclair Refining Company to circulate oil in their stills. It was not a centrifugal pump. We considered it a positive displacement rotary type of pump. That pump was used on those units for several years. That type of pump was never used on any other units.

The next type of pump we used was the Byron-Jackson Type of centrifugal pump, first used in 1924 in the unit at Martinez, California. We used those pumps through 1926 and possibly into 1927. During the

982 meantime we used other types of pumps; that is, the positive displacement plunger type of pump. On some units we had Dow surge pumps; others were Wilson Snyder piston type pumps, and National Transit pump. Most of the later units—the new units were equipped with the Dow surge type of pump. We installed those Dow pumps between the years 1926, '7, '8 and '9.

I testified that the transfer line temperatures at the outlet of the four inch tubes, was increased to about 900 F. The highest temperature, as the average for a run, recorded on the records on which I based this data was a temperature of 906 F. which was used

983 while charging a kerosene distillate of a gravity
983 944 of 42.1 A. P. I. and the yield was 36.59 Navy gasoline.

A kerosene distillate was used as a charging stock in some of the operations at Wood River and on the Martinez plant in California during 1923 and 1924. Some of our units ran on pressure distillate bottoms, which is the bottoms remaining after the distillation of the pressure distillate. That was done on these plants which had a maximum operating pressure of 150 to 200 pounds so the pressures used were within that range.

984 The usual charging stock to the 1-A and 2 units at Roxana, was fuel oil. They made some gas oil runs and made some kerosene distillate runs, but generally they were cracking fuel oil. The Cross unit that they had at Roxana was usually charged with light gas oil.

985 These Dubbs units were very flexible and you could use almost any kind of charging stock in them, and the refineries would use whatever stock they had. If they accumulated a large quantity of pressure distillate bottoms they would attempt to run those off in some cases. I know some of these installations were run on that type of charging stock in 1922, '3 and '4 when they were operating at these lower pressures. As an instance of an operation of that kind, I remember some
986 runs the Pure Oil plant at Ardmore ran on pressure distillate bottoms, using a pressure of probably around
987 135 to 140 pounds. That was done in 1926, approximately.

I have testified that the transfer line temperature when operating on kerosene distillate, was 904 to 906; and the A. P. I. gravity of the kerosene distillate on these runs was 42.1 and 42.4, which is pretty close
945 to a light gas oil. I would class it as a real light gas oil.

The No. 1 unit shown on PX 577 was in operation
988 when I arrived at Roxana. Among the improvements that I made on this unit, I connected these two sets of 16-inch vaporizing chambers together at the point H so as to equalize the pressure in these chambers and to make a better condition for the hot oil entering the
990 chambers from the two sets of heating coils. The uniting of all of these 16-inch chambers into what might be termed one unit made a little better condition

for regulation of the transfer temperatures, because all of the material that came through these two transfer lines was formerly equalized in the dephlegmator. So I just moved this equalizing point back to the outlet of these transfer lines.

991 In this furnace construction, there are four parallel paths for the oil to travel through the furnace. The only control we had of the flow of oil through these four paths was by regulating the amount of gases that passed over the top and passed downward through each set. In that way we would regulate the amount of heat imparted to those different coils which in turn would regulate the amount of the flow of oil on the in-
992 side. These four parallel flows of oil had to be
993 watched closely. It was mainly because of the very close observation required of this furnace No. 1 that we went to the single coil furnace of units No. 1-A and 2 and the 500-barrel unit which did not require so much attention of the operator.

995 946 I am acquainted with Mr. Carbon P. Dubbs and with Mr. Gustavus Egloff. Both are living today.

996 The single 4 by 30 horizontal expansion chamber used on the No. 1-A plant was the subject of discussion between Mr. Dubbs and others of the company. The
997 main reason why they decided upon the single chamber rather than the long tubes of No. 1, was because it had a larger coke capacity which we wanted because we wanted to make longer runs and wanted to go to deeper cracking. The size of that chamber, its coke-holding capacity, determined the length of the run.

997 947 In the No. 1-A, the effluent from the 4-inch tubes entered the expansion chamber through a vertical pipe which discharged above the liquid level in the
998 chamber.

The pipe in the reflux leg that extended below the point where the combined feed is taken from the leg was a trap that usually accumulated water in the early days and some coke settlings that happened to be washed up into the dephlegmator. At the end of the run we usually got a little slushy carbon out of that leg. I say "a little" because the pocket didn't hold very much. I won't say that it was cleaned every run. There was a drain line on there and when the unit came on-stream they would usually get an accumula-

tion of coke in that pocket and they would drain that.
999 At the end of the run they would open that up, and sometimes they would get slushy carbon out of there. We got slushy carbon on quite a few runs but it
1000 wasn't the usual thing.

In these operations we cleaned out this vapor line that extended from the reaction chamber to the dephlegmator. We did that after a good many of the runs. On some runs it was not cleaned. It was the usual practice, though, to run the tube cleaner through it just to make sure no carbon obstruction was in there. There was a cleaner made for that purpose,
1001 to fit that particular pipe. That was provided to all the licensees as part of their equipment.

The plant at the Riverside plant of Universal, in operation at the time unit No. 1-A was in operation, was not provided with a horizontal reaction chamber.

It had two vertical 10 by 10 chambers. I incor-
1001 948 porated the vertical reaction chamber in the No. 2 plant at Roxana. It was easier to clean the
1002 coke out of the vertical chamber than it was the horizontal chamber. It took considerably longer to get the carbon out of the horizontal chamber than it did out of the vertical chamber.

1003 In the vertical reaction chamber, in our earlier operations, we dug the carbon out from the bottom with pointed rods and worked a hole up through the coke
1004 and then dug the coke out that way. Later on we devised a method of suspending a chain first and then later on a cable throughout the chamber in horizontal layers in spiral form and the coke built around these cables. At the end of the run we would pull that cable with a hoist and in pulling it we would break out these layers of coke very easily.

I obtained a number of patents on means and devices for getting this coke out of these vertical reaction chambers.

After we had built this first still with the vertical reaction chamber at Roxana, we never used anything except vertical reaction chambers.

1005 The effluent from the coil entered the vertical reaction chamber through the top head pointing downward and discharged right at the top of the reaction chamber. Six try lines or liquid level lines were spaced at intervals on the sides of these reaction

chambers. They were used to determine where the liquid level was throughout the run.

1006 The pressure was maintained on this 500-barrel unit and on the No. 1 and 1-A and the No. 2 units at Roxana by a pressure gauge off the receiver tank
1006 949 at the back end. At Roxana the 16-inch tubes and in the 500 barrel units the reaction chamber
1007 were maintained under practically full still pressure in order to establish cracking conditions, in order that we would crack in the reaction chamber and in
1008 the system. The pressure was maintained in all parts of the system that were undergoing cracking at cracking temperatures.

"Q. Well, if you did not maintain this high pressure in the reaction chamber would you get any cracking?

"A. That would depend upon the pressure that you did maintain in the reaction chamber."

If you reduced the pressure in the reaction chamber to, practically, 10 pounds or atmospheric you
1009 wouldn't get very much cracking in the reaction chamber.

1011 In my direct examination I have called the Court's attention to three long runs. Each of these long runs was made with gas oil as a charging stock. In each one of these long runs the transfer line temperature was low, the highest temperature being 878 F. Two of these runs (PX 584, 585) produced a residuum having a high gravity, above 24 A. P. I. One of those
1012 runs (PX 583) produced a 16.5 gravity residue.

1013 We had no way of telling in this No. 1 unit the amount of oil that was going through the heating tubes. We had no meters of any kind.

We claimed that our process would crack the fuel oils which the other processes wouldn't touch. We
1014 considered that a real advantage, and we so told the licensees.

Whether the non-residuum type of operation was resorted to or the residuum type of operation depended largely upon the supply of charging stock
1014 950 that the refinery had available. If they had a limited supply and they wanted to get the greatest yield out of a given quantity of charging stock they would choose the non-residuum type of opera-

tion. The non-residuum operation was developed in our commercial units at several different places.

1016 There was no limit to the yield of gasoline that could be obtained from a charging stock with the
1017 Dubbs process. The higher the yield you obtained the more you would depreciate the residue. It all depended upon how far the refinery wanted to go in obtaining a high yield as to what he should do with his residue. The high yields making relatively heavy residue led to the non-residuum runs where they would make a complete disposition of the residue and process it while they had it in the system.

1019 The elimination of the residue is what led to the non-residuum operation. We considered it essential to eliminate the residue in some cases, depending upon the yield that the refinery wanted to obtain. The process had so much flexibility that in some of these operations a very heavy residue would be withdrawn and thrown out in a sump where it would solidify on the ground. Others, instead of withdrawing small amounts of residue, preferred to go to the complete non-residuum type of operations. Still other licensees preferred to draw a larger quantity of residue, and in some cases this residue was settled out in tanks and used around the refinery as fuel. That was all a question of disposal of the residue by the different refineries.

1020 After this non-residuum operation was developed, Universal in many cases recommended to its
1020 951 licensees to use that operation as one of the distinct operations of the process.

We probably sent out run summaries, and so forth, indicating what could be obtained by the non-residuum
1021 type of operation and recommending it in certain instances. In the early operations the temperatures of the non-residuum were in the same general order as the residuum. The capacity of the still was usually reduced because of the added recycling as a result of holding that residue in the reaction chamber and letting it crack down to coke. We increased the transfer temperature when we went to some of these non-
1022 residuum runs. It was higher than used on some of these longer runs on the gas oil. The range of the transfer line temperature on our non-residuum oper-

ation would fall between 870 and around 910. Later the temperatures increased to 915, some 925.

1023 The length of a non-residuum run with a 10 by 10 reaction chamber was about 36 hours or 48, after which the unit would have to be shut down and cleaned out. With a 10 by 40 it was about three or four days. Of course, the capacity went up too with the larger chambers.

1024 DX 590, entitled "Year Book 1924-1925 Dubbs Cracking Process", is a booklet put out and circulated by our company.

1026 DX 591 is another publication put out by the Universal.

DX 592, entitled "Progress of One Year with the Dubbs Cracking Process", is a publication of the Universal Oil Products Company.

1029 The vapors going up the vapor line into the dephlegmator in the processes at Roxana and the 500 barrel Dubbs unit are partially condensed under
1029 952 pressure. The vapor that forms the pressure distillate is also condensed under pressure. That is substantially the pressure of the system.

1030 At Roxana we fed overhead part of the time, split
1031 feed part of the time, direct feed part of the time. Split feed is a combination of overhead and direct feed. In unit No. 1 all the charging stock went into the dephlegmator. In unit No. 1-A the first runs were made charging the oil into the dephlegmator. Then some runs were made with direct feed, then later on split feed. And in the 500-barrel plants some overhead feed was used, split feed and direct feed.

1032 We operated some of the units with direct feed.

1033 In the 500-barrel unit at Roxana, they usually split the feed and fed part overhead and part direct.

The purpose of that was that the more charging stock you could feed overhead the better fuel economy you would have on the unit. When you are feeding into the dephlegmator there is no possibility of obtaining a sample of reflux only, because part of the
1034 raw oil was being mixed with the reflux.

953 *Redirect Examination by Mr. Thomas.*

1036 The yield of gasoline obtained from a non-residuum operation as compared with a residuum operation on the same charging stock was about ten per cent to twelve per cent larger.

1037 With heavier oils such as fuel oil the non-residuum operation was shorter than when lighter charging stocks were used such as topped crude or gas oil. The heavier oils have a tendency to form more carbon in the chambers.

1038 The first run made on Unit 1-A was with overhead feed but there were periods during that run that the feed was split and some periods when it was fed direct. After that there were runs made of the direct feed type.

Direct feed was also employed on the No. 2 Roxana unit. Referring to the standard 500-barrel Dubbs
1039 unit, some of those operations were direct feed. The direct feed operation is one where the charging stock was withdrawn from the raw oil tank by a pump and was charged directly to the inlet of the cracking coil rather than fed overhead to the dephlegmator.

In all of the standard 500-barrel units the vapor line connecting the reaction chamber to the dephlegmator was inclined upwardly.

1040 Expansion bends are necessary in handling the hot oil in a cracking plant. The lines reach approximately the same temperature as the oil passing through and have a tendency to expand because of the temperature and if provision is not made to take care of the expansion, or the lengthening of the
954 lines by using a flexible bend, a tremendous strain is placed upon the joints which may cause them to open up and leak. Such a leak of this material at that temperature causes a fire when the oil strikes the air.

In most of the non-residuum operations fuel oil and topped crude was used, and they are heavy in carbon-forming materials.

955 *Recross Examination by Mr. Thiess.*

1041 It is also true that we used topped crude and fuel oil as charging stock on our residuum run. A higher carbon content in the fuel oil and topped crude, than in gas oil forms more carbon in the reaction chambers.

1042 I think I said that topped crude and fuel oil had a tendency to form more coke in the reaction chamber, than gas oil. This tendency to form coke is only in the reaction chamber. It is not also true of the heating coil. There wouldn't be any greater tendency to form coke in the heating coil depending on the operating conditions. Normally, in the normal operations, we didn't figure we got any more carbon in our tubes on the heavier stocks than we did on the lighter stocks. The characteristics of the operation on which it mainly depended was how careful they

1043 were in handling the units, especially at the shutdown liquid level in the chamber. It had no effect on the running period at all as to whether it had a high potential carbon forming content or had a low potential carbon forming content such as gas oil. We made long runs on both types of operation. Of course, our runs on fuel oil were limited by the size of the reaction chambers, not necessarily by the tubes.

1043 Generally, there is not much difference in the heating of the oil in the 4-inch tubes whether you charge an oil with a high component of carbon-forming sub-

1044 stances, than one that has got much less, such as gas oil. That depends again on the reflux ratio that you are operating with.

1045 956 If they maintain the proper reflux ratio throughout the run you wouldn't have substantially any more carbon at the end of the fuel oil run than you would at the end of the gas oil run. I am assuming now that our operations were normal all the way through the run, and we maintained our reflux ratio that we set out to maintain at the beginning of the run, and at the end of the run on the fuel oil that we had the liquid level in the chamber at a sufficiently low point so as not to carry over any of these carbon-forming materials from the reaction chamber into the rest of the system. The only way of determining our reflux ratios was by the indication we would get in

1046 the temperatures of the combined feed going to the coil. If those temperatures were low we knew that the reflux ratio was low; if they were around 700, 730 or 740 we knew we had a good reflux ratio. Now just what the reflux ratio was we don't know. Temperature was the only indication that we had. That is the way we ran many of these early units. We continued to run them that way for some time.

1047 We used the direct feed after we had found out that feeding into the dephlegmator was a real fuel economy because in some cases we found we could get more capacity through the unit with direct feed.

1048 If we attempted to run at high capacities with overhead feed we would reach a point where the reflux would build up in the leg to the point that it affected our operation in our dephlegmator.

If you would take a unit operating at that same capacity, and feed a part of your feed direct, you
1048 957 would use more fuel in the furnace, but you could maintain that capacity of the unit that you could not otherwise obtain by feeding overhead. That has reference to the gravity feed unit.

1049 Higher capacity was the condition that made it economical to feed direct and feed nothing into the dephlegmator after we learned of this advantage of feeding charging stock into the dephlegmator. In other words, they were ready to sacrifice this economy in the interest of obtaining a greater capacity of the unit. Split feed was a partway measure between the overhead into the dephlegmator and the direct, and they usually fed as much oil overhead as they thought they could.

1050 Patents Nos. 1,638,735, (DX 593), 1,965,189 (DX 594), 1,937,959 (DX 595), and 2,039,797 (DX 596), are patents which were issued to me and which I assigned to the Universal Oil Products Company.

958 W. E. PERDEW:*

Direct Examination by Mr. Hall.

66** I am employed by the Winkler-Koch Engineering Co. in the capacity of operating and sales promotion since April or May, 1927. I have one qualifying share of stock and am a member of the Board of Directors
67 of the Winkler-Koch Engineering Company. I also have one qualifying share of stock and am a director of the Winkler-Koch Patent Company. I was unemployed prior to my connection with the Winkler-Koch Engineering Company.

66 I testified as a witness in the suit of Universal Oil Products Company *vs.* Root Refining Company in behalf of the Root Refining Company.

67 Derby Oil Co., Wichita, Kansas: Prior to my employment with the Winkler-Koch Company I was employed by the Derby Oil Company which had in operation four standard 500 barrel Dubbs units as of about 1923. In all these operations reflux condensate was recycled and residuum was withdrawn and not recirculated.

68 In the Root case I testified as follows:

"XQ. 150. You know, do you not, that had you made any attempt to recirculate any of the residual oil on these Dubbs units you would have immediately coked up your tube? Answer: I think you would have. XQ. 151. Is it not a fact that if you recirculated any substantial part of your residual oil you would coke up your tubes in a few hours? Answer: All these Dubbs stills that we had there? XQ. 152. Yes, on the Dubbs stills? Answer: Yes, I think that is right. XQ. 153. And in another case you so testi-
959 fied, did you not? Answer: In a patent infringement case, I believe I did. Mr. Thomas: XQ. 154. And did you not testify that either through error or accident your feed line dropped into your residuum tank and you coked up all four of your stills in about two or three hours? Answer: I testified to that, I believe. Yes, sir. XQ. 155. And did you not also

* This deposition was given July 20, 1937.

** Pages indicated refer to transcript of deposition.

testify that if through error in operation any of your residual oil juked out of your expansion chamber into your dephlegmator that you would also coke up in two or three hours? Answer: I did; yes sir. XQ. 156. And you recognize the meaning of the term 'clean circulation' in this industry, do you not?' Answer: I think I do. XQ. 157. That is not a new term with you, is it? Answer: I don't know when I first heard about it, come to think about it. XQ. 158. When did you first hear that term as used in the oil industry? An-
69 swer: I don't remember. XQ. 159. Did you hear it at the time of this litigation in this court room; is that the first time you heard of it? Answer: Oh, no, it has been several years ago when I heard it. XQ. 160. It is a fact is it not that you heard of that term and knew its meaning in the industry as early or earlier than 1927? Answer: I think so, but I wouldn't be sure. XQ. 161. Testifying in the case of Doherty versus Dubbs, on behalf of Doherty, Number 54666, were you not asked and did you not answer as follows: 'Question: Mr. Perdew, do you know what is meant by clean circulation? If so, will you state what the term means in the oil cracking art? Answer: Clean circulation means passing through the cracking coil in the heating element, oil which contains no residuals from the cracking operation.'

Question: It is well understood in the oil cracking art? Answer: I think it is. Question: What are the advantages of clean circulation? Answer: A clean feed through the heating element means that the heating element does not coke up nearly so quickly as it would if it fed with so-called dirty—or contained cracking residuals. Question: You so testified did you not? Answer: I think I did. XQ. 162. And you gave that testimony as early as 1929? Answer: Yes, sir. I think my conception of clean feed went back before that but how far back, I do not remember".

70 Shortly after I became associated with the Winkler-Koch Engineering Company I wrote a letter in May, 1927, to Mr. H. J. Halle of the Universal Oil Products Company (PX 83), as follows:

"Lubrite Refining Co. of 3504 Washington Blvd., St. Louis, should have some Dubbs units. They are operating 4 old Flemmings, at a loss I am sure. They are thinking about improvements. H. T. Ashton, an

old Pure Oil Co. man, is general manager. Mr. R. A. Frevert is Mr. Ashton's assistant, and I think he has quite a bit to say. Refinery is over in East St.
70 960 Louis. The company owns and operates a chain of well located service stations in and about St. Louis, and moves a good bit of its output locally. It has been making money right along. Now gets its crude by Pipe Line from Prarie.

"The Barber Asphalt Co. (1600 Arch St., Philadelphia, Mr. Frank Seamans, Senior V. P.) have quite a Roofing, etc. Plant at Madison, Ill. and along with it a most inefficient small Asphalt Plant. They, too, could get a pipe line connection with Prarie, being not very far from Wood River. I believe Mid-Continent crude, or rather fuel oil, can be run in a Dubbs something like Vickers operation at Potwin, Ks, and then the carbon-free hot residuum air blown to make a good asphaltum. They are running heavy Smackover crude and cannot use more than about 3 or 400 bbl. of asphaltum a day. I believe that is all 2 big units would make in a day. If this air blowing will work, you should sure sell them two units. I don't see, yet, why you did not get their job at Maures, N. J.

"Mr. D. Pyzel told me today that the Shell have an operation whereby they are making 32% gasoline from California fuel oil, with practically no coke, and very little Benzene insoluble in the residuum. He wouldn't tell me just what the operation is, but I surmise it did not require a large reaction chamber carried full. I am trying to interest him in our bubble decks and knock-back coils for his Trumbles running both crude & P. D. He is not the type that can be hurried, but I trust I laid a favorable foundation. If you and your associates can put in a good word for our decks and coils, I will appreciate it, and I know, that there are many places where we can save the refiner money, both in capital investment and in operation.

"By 'we' I mean Winkler & Koch Engineering Co. of Wichita. I am now associated with them. We are prepared to handle general refinery engineering and construction, with particular reference to fractionation equipment and tube stills.

"All three of us severally have ideas as to how the Dubbs Process as exemplified by the Marland job, say, could be materially improved upon. On general prin-

ciples we all here agree, and among us I am sure we have some very sound ideas. I believe Mr. Winkler has discussed some of them with you. Frankly, we
70 961 can see no profit in it for us to try to exploit these ideas to your licensees,—they won't pay for ideas,—and being post graduates of Universal, as it were, we are not going around talking up what we believe, at this time,* about cracking. Our business is selling towers, knock-back coils, and tube stills individually, or collectively in a complete unit or a whole refinery, exclusive of the cracking equipment. I did suggest to the White Star people yesterday that they look over Vickers operation and Derby's flash stills.

"The oil business looks a little better to me, although our little business has not shown any improvement as yet.

"I trust you are well.

Yours sincerely,
W. E. Perdew."

71 I was subpoenaed and in response to subpoena I went through the files of the Winkler-Koch Patent Company and Winkler-Koch Engineering Company up to and through 1932 and picked out letters and papers which I thought might possibly be in answer to the subpoena.

962 *Cross-Examination by Mr. Thiess.*

72 I was not in any way associated with Dubbs cracking units at any other place outside of the Derby Oil Company. I saw them in operation in other plants.

The Dubbs residuum referred to in my Root case testimony was made by cracking topped crude, by heating it in the heating coil and passing it into a reaction chamber by pressure, in which reaction chamber it cracked and fried down to a heavy viscous material containing much suspended carbon. It consisted of once cracked crude oil residues as well as residues from cracking in cycle.

I consider this a very heavy, dirty residuum.

73 It was entirely different from the residue produced by Winkler-Koch cracking stills. The Dubbs residuum

* We may think differently as time goes on.

produced at the Derby plant at that time was not merchantable fuel oil, whereas all of the Winkler-Koch residuum is merchantable fuel oil. The Winkler-Koch residuum contains no topped crude residue. That Dubbs residuum contained them all.

The residuum produced by the Winkler-Koch still can be returned in part to the cracking tubes without coking up the cracking tubes of the Winkler-Koch stills.

I had been in the employe of the Winkler-Koch Engi-
74 neering Company, when I wrote the letter PX 83, not more than two or three weeks. I was then employed as a salesman on commission only, selling Winkler-Koch products; I was not employed on a salary. In my statement in PX 83 I say, "All three of us severally have ideas as to how the Dubbs process exemplified
74 963 by the Marland job could be materially improved upon." I was referring to several Dubbs units which had recently been completed and were in operation at the then refinery of the Marland Oil Company at Ponca City.

I do not recall, now, what the improvement that I had in mind was, except those are not very good stills. They were run with no residuum operation and a lot of capital investment was involved for what they produced,
75 Although in this letter I state, referring to Mr. Winkler, Mr. Koch and myself, as follows: "and being post graduates of Universal, as it were, we are not going around talking up what we believe at this time." Mr. Koch never worked for, nor was he ever employed by, or in any way associated with the Universal Oil Products Company or any licensee that was operating Dubbs stills.

I was trying to court Mr. Halle's favor in getting him interested in me with the products I had to sell, which were distillation fractionation equipment and this equipment applied to, or could well be used by refiners putting in or assembling Dubbs stills, either in the preparation of charging stock for those stills or in the handling of the products produced by the Dubbs still, and I meant by that that from my association with Derby that I had had experience in handling products produced by the Dubbs stills. I meant by

that that so far as I knew Koch in his activities before I joined the Winkler-Koch Engineering Company had been trying to, and had sold refiners, fractionating equipment which could be used on Dubbs pressure dis-
76 tillate or on crude oil to prepare charging stock for Dubbs still but particularly he had had consider-
76 964 able experience in rerunning pressure distillates and at that time the manufacture of a merchantable gasoline from Dubbs pressure distillate was a real problem with all Dubbs licensees, and the same statement applies to Winkler, that in his activities in the engineering companies which he had formed he had sold considerable equipment in the way of fractionation equipment to refiners operating the Dubbs stills and that equipment had performed very well.

965 *Redirect Examination by Mr. Hall.*

76 Mr. Winkler of the Winkler-Koch Company had been employed for a number of years by the Universal Oil Products Company as a construction engineer.

966 DR. GEORGE GRANGER BROWN:

Direct Examination by Mr. Hall.

289 I live in Ann Arbor, Washtenaw County, Michigan. I am Professor of Chemical Engineering in the University of Michigan and I act as consulting engineer for various companies. I have studied the art of refining petroleum since about 1918 and have been active in the industry since about 1925.

290 I have acted as consultant to a number of the companies including Shell Petroleum, the Socony-Vacuum, the Standard Oil of California, the Sun, Phillips Petroleum, National Refining Company, and some others, as well as the Natural Gasoline Association of America, which is an association of the producers of natural gasoline, and as a special technical expert for the American Petroleum Institute, which is the trade association or institute of the petroleum industry.

I have also acted as consulting engineer to some of

the engineering firms which build equipment, help them in their design, and things of that kind.

I have never acted as an operator or a superintendent of a refinery. My experience has all been as a staff man, as a technical expert or consultant. I should regard that, however, as practical experience.

291 I have acted as director of research for the Natural Gasoline Association from 1925 to about 1932. I was awarded the Walker Medal from the American Institute of Chemical Engineers last year for contributions to the chemical engineering literature.

291 967 I graduated from New York University in 1917 with a Bachelor's degree, and later, about 1924, received a professional degree of chemical engineer from New York University. Then I have the Master's degree and the Doctor's degree from the University of Michigan.

I am a member of the following societies:

The American Institute of Chemical Engineers, the
292 American Petroleum Institute, the Society of Automotive Engineers, the American Society for Testing Materials, the American Chemical Society.

Petroleum is a naturally occurring oil found beneath the surface of the ground and composed predominantly of hydrocarbons. These hydrocarbons are not all alike. There are almost an infinite number of hydrocarbons found in petroleum.

A hydrocarbon is a compound or substance composed of carbon and hydrogen. The properties of the compound or the hydrocarbon are quite different from either the properties of the carbon or of the hydrogen, and the properties depend upon the structure of the hydrocarbon or the way in which the various atoms are held together within the hydrocarbon molecule.

The chemist calls the uniting forces between the hydrogen and carbon atoms bonds. A carbon atom has four bonds or four hands with which it may hold other atoms, while hydrogen atom has one bond or
293 one hand with which it may hold other atoms in combination in a molecule. In the molecule of the hydrocarbon the various atoms of carbon and hydrogen are held together by these hands or bonds between the various atoms.

293 968 The number of these bonds possessed by a single atom is called the valence of that atom in the hydrocarbon molecule. The carbon atom has four bonds or a valence of four. The hydrocarbon atom has a valence of one.

The composition of methane is one carbon atom with four hydrogen atoms, each one of the four bonds of the carbon atom being united to the single bond of one hydrogen atom, and that may be shown graphically by writing "C" for carbon, in the center with four
294 bonds coming outward from the carbon, each one of which is united to a hydrogen atom.

I will draw on a sheet of paper on the easel a methane atom. The way the chemist would represent a molecule of methane would be with a "C" for carbon, representing one atom of carbon, and the four bonds surrounding this single atom of carbon, each bond of which being united to a hydrogen atom in the manner which I have shown here. The bonds associated with hydrogen atoms are superimposed or merged into the bonds associated with the carbon atom.

There are four bonds coming out from the carbon atom, each one of which is united with the single bond coming from a hydrogen atom.

In the other compounds of higher molecular weight and of higher boiling point we have the carbons united to each other, such as this compound which I have shown and is known as normal pentane, "pentane" from the fact that it has five carbon atoms and "normal" pentanes because they are arranged in a
295 straight line or straight chain.

295 969 Now, methane, of course, is a gas which under ordinary conditions has a boiling point around 250 or 255 degrees below zero, pentane being a volatile liquid with a boiling point about 100 degrees or so Fahrenheit.

The "pentane" with the ending "ane" is used to represent this series of hydrocarbons in which all the bonds of the carbon atoms are saturated. There is only one bond between the various carbon atoms, and all the other bonds are saturated with hydrogen. Therefore, pentane is called a saturated hydrocarbon.

All the bonds of normal pentane are employed either in holding the carbon atoms to one another or holding

the hydrogen atoms to the carbon atoms, there being no free bonds. I think the word "saturated", however, applies to the fact that the compound is saturated with hydrogen. It couldn't hold any more hydrogen because there are no bonds available in that molecule to hold any additional hydrogen.

296 Methane is a very common gas. It has been called marsh gas because it is given off in the vegetable decomposition which occurs in marshes. It is the major constituent of natural gas, which is now used as gas fuel in Chicago, and it is a component of many gases such as coal gas and other gases of industrial importance.

There are unsaturated compounds, and there are even other saturated compounds of different structure. I think it might be well to indicate here another pentane, such as we call iso pentane, which has a somewhat different structure but the same number of carbon atoms and hydrogen atoms.

296 970 This compound called iso pentane, iso meaning the same number of parts or the same number of atoms in this case, but not of the same structure; and this iso pentane has different properties than the normal pentane, although it has exactly the same num-
297 ber of carbon atoms and the same number of hydrogen atoms, and is also a saturated compound. That is what is known as a branched chain saturated hydrocarbon. The branch is shown by this carbon atom which is tied to one of the carbon atoms in the straight chain. In normal pentane, there are five carbon atoms in a single straight chain, while in this iso pentane there are only four carbon atoms in a straight chain, the other one being attached as a branch to the straight chain.

The formula for these pentanes is written C_5H_{12}, being five carbon atoms and 12 hydrogen atoms; but the structural formula is, of course, different. There are other structures of hydrocarbons in addition to those that I have indicated.

All of these compounds really belong to one series, which are the saturated or paraffin series of hydrocar-
298 bons. Then there are other series which have a different ratio between the carbon and hydrogen. We have the unsaturated compounds, such as the olefins. There

you will have the compound known as pentane, if we use the same type of language I have used before. This is an unsaturated compound, because it is not saturated with hydrogen.

This carbon at the left end of the molecule contains, or is bonded to only two atoms of hydrogen; the other two bonds being used to connect it with the next carbon.

Now, on the face of it, it might seem that that
299 971 would cause these two carbons to be held very tenaciously together, but that is not the case. These double bonds as drawn that way really represent a sort of, a couple of active bonds, one active bond being to each of these two carbons, so that these two bonds may be satisfied by the absorption into the molecule of additional hydrogen atoms or other atoms. So that compound is called unsaturated. It is not holding its full quota of hydrogen; and compounds of that kind are much more active than are the saturated compounds, for the reason that they have this really free bond on two of the carbon atoms.

The overall formula for that would be C_5H_{10}; and of course compounds of this kind can be straight chain or branched chain, in the same way as the saturated compounds.

We have an additional type of compound called cyclo compounds; in this case, cyclo pentane, which has the same over all formula as this unsaturated pentane, but which is a saturated compound because of its different structure. In other words, if this carbon at the one end of the pentane molecule simply unites itself with the carbon at the other end of the pentane molecule and the hydrogens rearrange themselves, we have this compound known as cyclo pentane which has the same formula as the unsaturated pentane, but is a saturated compound.

Then there are other groups in which the cyclic structure is preserved but they are unsaturated; and also we have other compounds which have two double bonds, which are less saturated than these olefins.

The latter compounds are diolefins or the dienes,
299 972 such as this compound, should be, using the same
300 nomenclature, pentediene, has two of these double bonds or unsaturated linkages, and is more unsaturated than the pentene or the olefin series, and is still more

active chemically. I might find all of the structures that I have represented in the same hydrocarbon molecule or compound. One compound may embody many of these different structures. Maybe a combination of a cyclic straight chain, a branch chain, an unsaturated chain, all in one molecule or one compound. There are almost an infinite number of combinations and permutations of these different structures. We find all types of these compounds formed during cracking.

When we have a large molecule with a large number of carbon atoms in it, and crack it or break it into smaller pieces, we will find that always we are short on hydrogen, so that the compounds formed from a cracking operation in general are more unsaturated with respect to hydrogen. So that these unsaturated compounds are characteristic of the products from a cracking reaction.

301

All these elements or compounds such as I have illustrated do not lie in a single plane. For simplicity we have written them on a single piece of paper; but actually they occupy three dimensions. Of course, this is fundamentally a theory of chemists, but it has been so satisfactory in explaining and predicting reactions that I believe all chemists now regard these structural formulae as really facts. I conclude that these hydrocarbons have these forms because they act as if they had them.

We are able to predict reactions that will occur and may occur and have not yet been observed, by means of them. Therefore, we place a great deal of confidence in these structures.

301 973

I cannot recall right now just when the theory of the atoms being connected by bonds or valences was first advanced, but I believe it was somewhere in the latter part of the nineteenth century. However, this theory is generally accepted now. I believe that all chemists are now willing to accept the formulae as really facts.

302

It is possible to effect the separation of petroleum into what might be called characteristic fractions other than by cracking. When we separate petroleum into its fractions ordinarily we do not crack the petroleum. The separation is usually effected by distillation or vaporization, in which we form vapor from a liquid and then condense that vapor out of contact from the liquid. It is based on the principle that the composition of the

vapor is different than the composition of the liquid from which it is formed. The proportion of the more volatile or simpler molecules being greater in the vapor than in the liquid. So by successive vaporizations and condensations we can concentrate the more volatile or simpler structures in the condensate or the distillate, as it is called, and leave behind the high molecular
303 weight, the high boiling material; and that is the basis for the refining of petroleum by distillation, in which petroleum is separated into various commercial products, each of which in itself may be extremely complex chemically but which has properties based primarily upon the volatility or the boiling range of the ma-
303 974 terial contained in that fraction.

These fractions are substantially standard as to boiling range. We have, for example, the most important product from petroleum, gasoline, which is now rather well standardized, having a boiling range generally recognized as from about 80 to 400 degrees Fahrenheit.

Then we have another commercial fraction known as kerosene, which has a boiling range from about 330 or 350 to about 525. Sometimes a similar material is used as a furnace distillate for domestic fuel.

Then we have a still heavier or less volatile fraction which is not so well defined as these, generally classified as gas oil, which may have a boiling range of anywhere from about 500 or 600 degrees upward to 750 or higher.

304 Then in the ordinary operations, where we are not making lubricating oil, the residue left behind as a liquid after these products are removed would be classified as a fuel oil or a reduced crude oil, and that material will contain materials or compounds having boiling points from about 400 or 500 degrees up to well over 1000 degrees Fahrenheit.

The old practice which was carried on for a great many years in the petroleum industry was to charge a so-called shell still, the shell still being similar to the shell in the Burton-Clark model shown here; and then start the fires underneath the still. And as the temperature of the oil increased, vapors would form and pass up through the line leading away from the still. The vapors would then be condensed separately from

the still, and collected in a tank or receiver. This
305 975 operation was conducted in such a manner that the stream of condensate or condensed liquid flowing from the condenser could be sampled and inspected by the operator through a so-called look box, and he would sample the stream passing through this look box and continue running this stream of condensate into this first tank in which he would collect what was then known as crude naphtha, until the stream would reach a gravity of about 48° or so in the Mid-Continent practice, at which point he would switch the stream or make a cut, as he said, into a second tank. Then he would continue running into the second tank until the gravity of the stream had decreased to about 38 or thereabouts, in refining or running Mid-Continent oils, and that stream would be another crude cut which would be refined to make kerosene. Then he would make another cut at that point, and turn that stream into a third tank, continuing the distillation until the gravity had decreased to perhaps 30 or 32 degrees Baume or A. P. I., as we say, and that cut would represent the gas oil fraction.

Now, the crude naphtha, which was in the first tank
306 or the first cut, would then be refined by chemical treatment and then redistilled to make the final product, gasoline; and that has a boiling range somewhere from about 80 or 100 degrees up to perhaps 400 or 450 in those days. And then the second cut would be refined to make the kerosene of commerce, having a gravity of about 42 or 43 and a boiling range from about, say, 350 up to about 525, or possibly 550. And the third cut would constitute the gas oil, without any further refining. What was left behind in the still would be reduced crude.

306 976 That was the operation as conducted for many years in the petroleum industry.

The look box that I referred to was simply a box built in the pipe line that had a glass in one side so that the operator could look down in the box and see the stream running through there, and it had a cover that could be raised so the operator could dip down in the stream and take out a sample. It was virtually an enlargement of the pipe through which the stream was running with a pipe leading into the look box from
307 which the stream flowed from the condenser, and then

a pipe leading out of the bottom of the look box through which it flowed to the tank. They still use those.

In making these several fractions, there was some overlapping between each of the adjacent fractions so that in the fraction of a relatively lower boiling point there would be some of the higher boiling point material, and in the next fraction there would necessarily be some of the material of the lower boiling point fraction.

It is due to the fact that these hydrocarbon compounds all have a certain tendency to vaporize, or a certain volatility. Some of them are very volatile, and some are almost non-volatile. And under the conditions at which this distillation is conducted, we will find that the most volatile materials will concentrate themselves or be present in very large proportions in the vapor, while the less volatile material will be present in much less proportion or lower concentration in the vapor, and the high boiling material, which is practically non-volatile will be present only to a very limited de-
308 977 gree in the vapor. But the vapor which passes off from the still, theoretically at least, will contain some of every compound which is present in the liquid. It will contain those compounds which are volatile in large concentrations, and those compounds which are less volatile in less concentration; so that the separation is never sharp in a single distillation of that kind.

Taking a typical Mid-Continent crude as an example, approximately 25 percent of the crude oil may be recovered as gasoline by simple distillation.

The kerosene recovered is much smaller than that, usually about 5 to 7 percent, sometimes a little more and sometimes a little less. Usually about 30 percent
309 of the crude oil could be recovered as gas oil.

Topped crude is a term which is not particularly definite. It may represent the crude oil which is left as a liquid after the gasoline is distilled out of it, or it may represent a residue after the gasoline and kerosene are distilled; but I should say that topped crude might represent approximately 70 percent or so of the crude oil.

I have mentioned two gravity scales, one Baume and the other A. P. I. The Baume scale is substantially identical with the A. P. I. scale. The reason for the two

names is that a number of years ago the petroleum industry began using Baume gravity, which was defined slightly differently than the Baume gravity used by the chemical industry. In order to avoid confusion, the Baume scale used by the petroleum industry was defined as degrees A. P. I., meaning American Petro-
310 978 leum Institute. So when we use the Baume or degrees A. P. I. in petroleum, we may regard those as substantially identical.

The other gravity scale which is in general use is the specific gravity, and these two are quite different, that is, the specific gravity and the A. P. I. The specific gravity, of course, being the density of the material divided by the density of water. The material which has the same density as water has a specific gravity of 1. If it is more dense than water, its specific gravity is greater than 1, and if it is less dense than water, then its specific gravity is less. In the Baume or A. P. I. scale this situation is reversed. The material having the same density as water has an A. P. I. gravity of 10. If its density is less than water, it has a higher A. P. I. gravity. I believe approximately 70 A. P. I. gravity corresponds roughly to about 7/10 specific gravity.

In the petroleum industry today the Baume scale or the A. P. I. scale is used practically exclusively in de-
311 noting gravity. In the Baume scale, the lighter the material the lighter the gravity or the lighter the material the higher number it has in the scale. Consequently,
312 taking gasoline in the Baume scale the gravity is about 60 to 68. It depends upon its character and boiling range, and so on, but at the present time it will usually fall within those brackets.

Kerosene is considered a heavier material and has an A. P. I. gravity of about 42 to 44.

The simple distillation operation is considered to be physical, where we simply separate materials present in the crude oil according to their boiling range or
312 979 volatility without causing any chemical change.

The pressure that ordinarily prevails in the simple distillation operations is about atmospheric. At
313 times they go to reduced pressure or partial vacuum when it is desired to distill heavy fractions such as lubricating oils and materials of that kind.

If one were carrying out a simple distillation and he found that too great a proportion of the less volatile material was coming out, he could remedy that without changing the temperature of the oil body undergoing distillation.

The composition of the vapor formed in the simple distillation, or the relative proportion of the high boiling material in the vapor, depends upon the temperature and pressure at which the vaporization is conducted. If the operation is conducted at a constant pressure, the temperature may be lowered to decrease the proportion of these high boiling materials; or if the operation is being conducted in such a way that the temperature cannot be conveniently controlled, then the same result can be obtained by varying the pressure. So that the operator can either increase the pressure at constant temperature or decrease the temperature at constant pressure in order to decrease the proportion of the high boiling material in the vapor.

314 The simple distillation that I have referred to is a function of temperature and pressure. The five bottles containing oil samples are specimens from samples which I gathered in 1937 from the Shell Refinery at Wood River and represent these typical fractions

314 980 produced by simple distillation.

This sample numbered 1 is the Mid-Continent crude oil which was supplied to that refinery for treatment. The sample No. 5 is the gasoline removed from that crude oil by straight simple distillation,—I should say, straight distillation rather than simple distillation, because it was done under fractionating equipment. The letters on the sample, S. R. means "straight-run". That means gasoline produced in the distillation of the crude oil and not in the cracking.

Sample No. 4 is a sample of kerosene produced in the same way and at the same time from this Mid-Continent crude.

315 And sample No. 3 is the straight-run gas oil produced from that crude oil by straight run distillation.

And sample No. 2, is the topped crude oil which is the liquid residue left after the gasoline, kerosene and this gas oil has been removed from the crude oil. This gas oil is a relatively light gas oil. My recollection is it was about 37 degrees. So that this so-called topped crude may be a heavier crude than might be

obtained from other operations where the gas oil is not removed, and it might be a lighter or less dense material than would be obtained if the heavier gas oil had been removed, but in general it represents what might be called topped crude.

(The five samples just referred to by the witness are admitted in evidence as PX 517.)

Mr. Hall: Q. You said that these distillate samples of Exhibit No. 517 were not produced by simple distillation, as I understand you; is that correct?

316 981 A. Well I corrected myself when I referred to it as simple distillation, for this reason, that the term simple distillation usually is intended to convey the type of distillation which I had previously described as the formation of the vapors and then condensing them separately; while fractional distillation as distinguished from simple distillation refers to the operation as conducted in fractionating towers in which we have really successive distillations or vaporizations and condensations on every tray in the column of the bubble tower. And I wish to correct myself, I did not want to create the impression that these samples were produced by simple distillation in the sense that they were produced by the old still operation; they were produced by a more modern plant.

Q. But as to the character of the produc except that the fractions might be more sharply cut at their adjacent ends, there would be no difference between

317 them had they been produced by simple distillation?

A. That is right.

When I speak of fractional distillation I mean the apparatus will have a vapor pipe leading from the still and discharging into a fractionating tower of the bubble cap type. This type of fractionating column is equivalent to a plurality of stills; the lighter of these various fractions will come overhead from the tower with your gasoline fractions. The other fractions would be removed as side streams from the various plates in the tower. From a practical standpoint, except that the bubble tower is a little more

318 efficient than the other scheme, there is no great

982 difference between the two processes or the products which are produced. The products from the fractional distillation are more sharply separated.

I am familiar with the Burton process which is pictured in PX 504. Although I do not know from my own personal experience because I have never charged these stills, I believe the charge was a gas oil of about 32° A. P. I. This is general knowledge since it is described in practically all the publications or textbooks relating to refining and is known throughout the world wherever they carry on refining. The operation carried out in the apparatus pictured in PX 504 is a distillatory cracking operation in which the gas oil charged to the still is heated under pres-
319 sure and the vapors subjected to reflux condensation as they pass up through vapor line 4 and the so-called harp 5. It is a cracking operation.

A cracking operation is an operation which is conducted for the purpose of changing the chemical structure of the compounds present in the oil. I might make an analogy which will perhaps help a little to make clear the difference. In straight run distillation in which we separate the material present in the crude oil into different fractions, such as gasoline, kerosene, gas oil and topped crude there is no change in the compounds brought about, in much the same manner as the operation of a screening plant at a gravel pit where the coarse gravel enters the screens
320 and the fine sand is first screened out; then it goes to the next screen where the next coarser material is taken out and so on.

That is equivalent to straight run distillation where we simply separate the material which is present in the crude. And when we come to a cracking oper-
320 983 ation, that is more comparable to the crushing operation in which we may have rock that we wish to crush down to sand fine and coarse in which the material goes through a crusher and in the crushing operations materials of all different sizes are produced. Then that product of the crusher goes over the screens and the fine material is removed, and that material which is not sufficiently crushed to meet specifications will be separated and returned to the crusher for further operation. So far the cracking operation is therefore similar to the crushing operation, and the cracking occurs in the still 1 as shown on PX 504, producing a cracked product which consists of material of all different volatilities. Then

this mixed material passes through the operation
321 which corresponds to the screening operation. The vapors pass up through line 4 into the harps 5, wherein the high boiling material which is not sufficiently cracked to be incorporated in the desired final product, is condensed from the vapors as they pass through 5, and that condensate is returned back through the vapor line 4 to the still for further treatment. Because this material which is returned to the still is condensed from the vapors, it is referred to as a condensate. Because it is reflux or returned to its original source, it is called a reflux. So we have this product of intermediate volatility called reflux condensate which is screened out of the vapors as they pass up through line 4 to harps 5 and is returned to the still. That material which does have the proper volatility to be incorporated into the desired product, which is known as pressure distillate, passes on through the condenser coil 6 and is collected in the receiver 7 in the receiving house.

321 984 Now, of course, along with that pressure distillate is produced some gas, just as we might produce some material which is finer than we desired
322 in the crushing operation, and that material, gas, separates from the pressure distillate in the receiver.

Now so far, the two operations are very similar but there is a difference, an important difference between the crushing operation and the cracking in that the cracking operation we produce these unsaturated compounds which are very active at the cracking temperature. And these compounds unite and form material of still higher boiling point and of a still more unsaturated character. These materials may be called polymers, meaning that they are formed by the coming together of many other materials. So that accompanying the cracking action we find not only the production of more volatile material, such as the desired pressure distillate, and the material of intermediate boiling range, the reflux condensates, but also some material of very high boiling point which is of a higher boiling range even than the original material, and which is highly unsaturated and very active at these temperatures.

323 The gas formed in the cracking reaction is called by the industry non-condensable gas because it is not

condensed in these operations. This gas performs an important function in the cracking operation.

In the ordinary cracking operation it is practically a waste product and for many years was used only as fuel, but recently in the last few years very important uses have been found for this gas. Because it contains these unsaturated hydrocarbons, which are very active, they have been able to polymerize
323 985 these unsaturated compounds in the gas to produce gasoline from them. And perhaps you have heard recently of the development in this country in which they are going to make synthetic rubber from buta diene which is one of these compounds which was formerly regarded as a waste product. So at present the cracked gas does have important industrial value, but until very recently it was primarily a waste product and used as fuel.

324 In the operation of the Burton process, it performs the function of being the means by which the pressure can be controlled and maintained on the operation, because the release of this gas from the separator is the point of control for that pressure.

Pressure is important to the cracking operation. In the absence of that pressure the gas oil which was charged to the still would be almost completely vaporzied out of the still before we ever got the still up to a good cracking temperature.

The temperatures used in the Burton process in cracking varied from about 700 up to about 750 degrees Fahrenheit, sometimes a little more, sometimes a little less, and that temperature serves the purpose of heating the oil up to such an active state that active cracking would take place. The rate of cracking is
325 almost wholly a function of the temperature, that is, except in some of the modern developments of catalytic cracking, and other operations.

325 986 Temperature affects the molecular structure in the cracking of the molecules. The theory is based on the kinetic theory that the atoms in the molecules become active or agitated as they are heated to a high temperature, and finally they get so agitated that they break apart. It is perhaps a crude way of putting it, but that represents the picture many of us have.

326 Cracking involves a chemical reaction. The material

which is cracked undergoes a chemical change. New compounds are formed and the old compounds are destroyed. It involves both dissociation and reassociation of the molecules making up the oil undergoing treatment. We get the cracking or dissociation into smaller molecules of greater volatility and accompanying that the polymerization, or, I think you called it, association of material into high boiling material.

I am familiar with the expression that the carbon is the "bane" of the cracking process and I think it is true. The baneful effect is exemplified in the cracking operation because in order to crack oil we must heat it to this high temperature. In order to heat it to the desired temperature, we must force heat into the oil through some vessel or tube in which the oil is contained.

327 Now in a rough way, the flow of heat from the fires in the furnace into the oil through the metal tubes or the metal of the still, may be regarded as somewhat analogous to the flow of water through a pipe. As long as the metal is clean which contains the oil there is no particular resistance to the flow of heat as the metal is a good conductor and the heat flows freely through the metal into the oil. Now if we
327 987 put anything in the way of that flow of heat, as occurs when carbon forms and deposits on the inner surface of the metal, the flow of heat is restricted because carbon is an insulator to the flow of heat, and as we restrict the flow of heat, the heat to a certain extent may be said to back up in the metal so that the metal does not have a chance to pass its heat on to the oil so rapidly with the result that the metal rapidly approaches the temperature of the fire; and as the metal gets hot its tensile strength decreases, and if the vessel is under pressure or the tubes are under pressure, the point may be reached at which this metal will not have the tensile strength to hold the oil inside the tube or inside the still. When that point is
328 reached there will be a rupture of the tube or of the still and oil will flow out into the fire box with disastrous results. So that the carbon formed accompanying the cracking operation is a very dangerous thing from the standpoint of safety, and also impedes the heating which is necessary to carry on the process.

329 I am familiar with the five bottles containing samples of oil which were shown to me. Four of these, those numbered 1-C, 2-C, 3-C and 4-C, are samples which I took in 1937 and sealed at that time from the Wilcox Dubbs plant at Bristow, Oklahoma; sample 1-C being the topped crude which was charged to the unit.

330 And which material is very similar to the sample of topped crude which you showed me yesterday produced in the straight run distillation of petroleum,
330 988 that topped crude, of course, being the liquid which is left after the removal of gasoline and some kerosene or other material of that nature.

I do not recal. now whether this particular topped crude contained the gas oil or only a part of it or none of it. My recollection is that that topped crude is about 24 gravity in which case it would contain most or a good part of that gas oil fraction, but I am not sure now.

These samples of oil are characteristic of those fractions of oil generally supplied to or resulting from the Dubbs operation such as I am thoroughly familiar
331 with. This is a typical plant and was so chosen for the taking of these samples, giving products typical of the product obtained from such plant when charging material such as this topped crude. It is a representative plant.

My recollection is that the source of the topped crude is from a Mid-Continent crude. Sample 2-C
332 is the combined feed; that is, it is the mixture of this topped crude with the reflux condensate which was fed to the inlet end of the cracking coils. The combined feed consisted of the topped crude and the reflux condensate was not contaminated to any extent with the residue which resulted from the vapor separating action which occurred in the vaporizing tube C of the Dubbs patent. The residue which was separated in the chamber was withdrawn from the bottom of the chamber and only the vapors were allowed to pass up through the vapor lines into the reflux condenser or dephlegmator, so that the combined feed composed of topped crude and reflux condensate is completely free from the residue, which was withdrawn from the bottom of the separating

chamber; and the sample numbered 3-C is that
332 989 residue which was so withdrawn from the chamber.

333 After the combined feed passes through the cracking coil it is discharged into a vaporizing chamber wherein vaporization or separation takes place. The vapors passing overhead and the non-volatilized oil remain behind and are withdrawn from the plant at the bottom of the vapor separator. As far as the vapors are concerned, it is left behind. This non-volatilized oil is represented by sample 3-C which is marked "residuum". The vapors that go overhead from the separating step are subjected to partial condensation which separates from the vapors by condensation the material which is too high boiling to be included in the pressure distillate or the desired
334 product, and those vapors which are thereby condensed are called reflux condensate, and that reflux condensate is returned to the inlet end of the cracking coils and constitutes part of the combined feed. The vapors which are not condensed in the partial condenser pass on overhead as vapors and are later condensed to form the pressure distillate, which is the desired product.

I did not take the sample marked "Reflux Condensate, Single Coil Operation." It was supplied from the laboratories of the Universal Oil Products Company at Riverside as representative of such a reflux condensate in a single coil operation. I was unable to get a separate sample of this material in the Wilcox plant and this is submitted to fill the gap, as it were. It has the same appearance as the reflux condensate which is formed in these Dubbs plant which I am familiar with.

335 The sample marked 4-C is a sample of pressure distillate which I took from this plant and was
335 990 produced in connection with the samples 1-C, 2-C, which I have already mentioned. This is liquid which is collected after the final condenser in the receiver and constitutes the pressure distillate.

Mr. Thiess: Q. The same appearance, you mean as to color?

A. In general it has the same apparent characteristics as such reflux condensate. I have not made tests on it.

Q. Then what are the characteristics of it?

A. The fluidity, and then the color is consistent with those, and so on. It is representative.

336 (The five oil samples just referred to by the witness are admitted as PX 518.)

I am familiar with the model of an oil cracking plant which is in evidence as PX 511. I am also familiar with the drawing of an oil cracking plant which is in evidence as PX 509. I am familiar with the apparatus and process which is disclosed in the Dubbs patent in suit, a copy of which is in evidence as PX 500. I have also considered the application as filed for the Dubbs patent in suit, the entire file wrapper, the history of the application for that patent being in evidence as PX 501.

337 PX 511 is a scale model of the apparatus shown in the figures of the patent.

PX 509 is an isometric drawing of the apparatus disclosed in the patent with, I think, the omission of the tank L and some of the lines which are connected to it.

The Tank L of the patent relates to a modified form of invention disclosed in the patent. It relates to an alternate procedure which is described. The inscriptions appearing on PX 509 substantially compare with the descriptions found in the Dubbs patent in suit.

337 991 The color is placed on the drawing (PX 509) to aid in distinguishing the different parts of the apparatus. The Dubbs patent and apparatus may be described as follows:

338 The apparatus is shown in Figure 1 and Figure 2 of the patent. Referring first to Figure 2, the high pressure pump marked J toward the upper right hand side of the figure, is the pump which feeds the charge to the unit. This charge passes through the line J′ and enters the cracking tubes B. As it goes 339 into the cracking tubes B, it is joined by a stream of reflux condensate coming into this charging stream through the pipe F′ through the valve H^5, so that these two streams which constitute the combined feed are united before they enter the cracking tubes B. In the cracking tubes B the material being treated receives all of its heat that it receives during the operation. At the outlet of the cracking tubes B, shown

at the left hand end of the lowermost tube is connected the transfer line, which is shown not too clearly, as a line conducting the material from the outlet of the cracking tubes B over to the far or right hand end of the vaporizing tubes C.

The cracking tubes that I have just referred to are colored red in drawing 509 and from the last tube there is a line leading down, which is also colored
340 red and which is the line I will call the transfer line which passes to the vaporizing tube C. The pump marked J on drawing 509 is the pump that I have just referred to. From that pump there is a line marked J′ and the line is also designated feed line.

That is the line that leads to the inlet end of the
340 992 cracking tubes B. On the same drawing there is a line colored in orange and marked F and F′. This is the reflux line which discharges into the feed line to make up the combined feed. The material transferred from the cracking tubes B into the vaporizing tubes C enters these larger tubes and the velocity is immediately decreased. In these vaporizing tubes C, the vapors separate themselves from the liquid and, as stated in the patent, the liquid residue occupies the lower part of these vaporizing tubes C as
341 indicated approximately by the brown coloration on the drawing Exhibit 509.

The tubes B are 4 inches in diameter and the tubes C 10 inches in diameter.

The vapors which separate from the liquid in the vaporizing tubes C are represented by the blue coloration in these tubes, and these vapors pass upward out of the vaporizing tubes C, through the four vertical lines marked D. As the vapors leave the tops or upper ends of these tubes D, goose-necks are provided so that the vapors pass downward into the vapor tubes E which slant upwards towards the header, G. As soon as these vapors enter the vapor tubes E they come in contact with liquid or reflux condensate which is flowing back down through the slanting tubes E. There is then a heat interchange between the vapors and the liquid and we have a counter current
342 flow of the vapors passing upward through the slanting tubes E, through the header G and up through the aerial condenser marked G′, and that liquid condensate flowing back down through the aerial con-

denser, through the header G and through the slanting tubes E.

342 993 This constitutes the partial condenser or reflux condenser which separates from these vapors those materials of high boiling point which are not desired in the final product. So that this liquid condensate of insufficiently cracked material flows back down through the tubes E but is prevented from flowing back to the vaporizing tubes C by the goosenecks, so-called, on the upper ends of the tubes D. But this liquid condensate is collected in the pipe F, and flows through the pipe F referred to as a drainage line in the patent, into the pipe F', through the valve H^5 and joins the fresh feed and constitutes part of the combined feed, as I have described.

The vapors which are not condensed in the partial condenser or aerial condensing system, the slanting tubes E, G, and G', pass on as a vapor through the line G^2 and enter the final condenser or the water cooled condenser G^3 where they are condensed forming the
343 pressure distillate which passes on into the separator where the non-condensable gases are separated from the pressure distillate.

The residue of the vaporization, which took place in vaporizing tubes C, indicated by the brown color at the lower parts of these tubes, is removed through the line K and the valve H' and withdrawn from the system.

The oil reaches its highest temperature in the cracking tubes B.

The tubes C are heat insulated, as stated on the first pages of the patent in the second column, beginning line 99:

343 994 "A light fire may be maintained under the tubes C as shown in the drawings or said tubes may be heavily insulated with cel-o-cel insulating material or any other well known insulating material to prevent loss of heat by radiation and thereby dispense with the fire under the tubes C."

So that the tubes C are heat insulated, either by some insulating material or by surrounding them with hot gases so as to prevent the heat loss from the oil in the tubes C.

344 In the cracking tubes B the fresh feed and the reflux condensate constituting the combined feed, re-

ceives all of the heat that this material receives in passing through the operation. These tubes are called the cracking tubes and the heating tubes. The oil is heated and cracked in these tubes. As the combined feed passes through these tubes, there is a generation of some vapors within the oil as it passes through these tubes, and this mixture passes through in a turbulent condition with vapor retained in the oil in what may be called a foamy mass. There is no separation of the liquid from the vapors or the vapors from the liquid in these tubes B.

In other words, the two travel along at the same speed.

345 If the vapors separate from the liquid they no longer travel through the tubes together and the vapor may pass through much more quickly than the liquid; that is, the operation which is indicated and described in the patent in the vaporizing tubes C. That operation is the separation of the vapors from the liquid. The patent says, page 1, line 52:

"C are the vaporizing tubes."

And then it describes what happens in these vaporizing tubes, beginning in the second column on page 1, line 78:

345 995 "Said oil is then passed into the tubes C which are only partially filled with the oil and as the oil passes through these tubes, there is a liberation of vapors from same and which vapors pass up through the vapor tubes D,"

and so forth.

346 And that again is referred to in the example given on page 2, beginning about line 40:

"The heated oil",—that is after passing through the B tubes,—"The heated oil then passes to the 10 inch coils C which are maintained about half full of oil and wherein vaporization takes place. The residue is constantly drawn off through the pipe K to a suitable storage."

So that the operation which you have described in which the vapors separate from the liquid takes place in the C tubes but not in the B tubes.

Vapors are generated in the oil as the oil passes through the cracking tubes. Bubbles of vapors will be generated within the oil and the mass may be called a foamy mass.

347 Now referring to the example given on page 2 beginning line 35 which says:

"Gas oil from Mid-continent crude oil, such as Kansas, or Oklahoma, oils of 32 to 36 Baume gravity is taken and continuously supplied to the pump J and thence to the 4 inch coils D which are subjected to a temperature of 750 to 860 degrees F."

And farther down, beginning line 55:

"A pressure of approximately 100 pounds to the square inch is maintained on the oil during treatment which is caused by the pressure of the generated vapors. This pressure is regulated by the valve H."

Under the conditions of 750 degrees F and 100 pounds pressure, this gas oil as described would contain at least 20 or 25 per cent by weight of gen-
347 996 erated vapors of the oil as it passes through the cracking tubes B. At the higher temperature, 860 degrees F. under the same pressure conditions this oil would contain upwards of 90 percent by weight of vapors generated within the oil as it leaves the cracking tubes B. Of course at the entrance end of the cracking tubes B the entire stream is liquid and there is no vapor generation, but as the oil is heated to higher temperatures as it passes through the cracking
348 tubes B, vapor generation will start, increasing in amount until it reaches these maximum figures which I have given as representing the condition as to vapor generation at the outlet end of the cracking tubes B.

Q. In the first claim of the application as filed by
349 the Dubbs patent, a process is defined, the first step of which reads as follows: "Consisting in passing the oil through a heating coil in a cracking zone"; and the second step then continues, "passing the oil and generated vapors into a vapor chamber."

What do you understand is there meant by the generated vapors?

A. Exactly what I have been trying to describe; that part of the oil in the liquid phase is converted into what we call bubbles of vapor, as it passes through the cracking tubes B, so that the material leaving the cracking tubes B consists of oil and generated vapors.

The presence of the liquid with these generated vapors in the condition as it exists in these tubes means that there will be no separation of liquid residue in the cracking tubes B; that all of the material will

pass through the cracking tubes B together, and
350 997 there will be no heavy ends of heavy liquid left behind which, if left in these tubes which are heated, would rapidly form carbonaceous deposits known as coke. And the fact that this liquid and vapor, as a mixture, passes through the tubes together means that these heavy materials are in solution in the liquid and are carried out of tubes B at the same rate as the vapors and the other liquids passed through the tubes B.

A foamy condition existing in the tubes signifies the presence of a liquid.

A foam is a mass of liquid in which there are bubbles of vapor, the liquid being the continuous phase with the vapors dispersed in it, which is the condition which exists towards the outlet of these cracking tubes B.

The importance of the liquid being in the external phase and the vapors which have been generated being in the internal phase is that it means that the liquid is carried through with the vapor, at the same velocity, and that there is no separation. Whatever liquid is present is held in solution with the other liquid which is present, and the whole mass travels through the tubes together.

351 Q. Now, you referred to the return of the condensate, the reflux condensate, from the partial condensing system of the apparatus to intermix with the fresh feed, to form a combined feed which enters the inlet end of the cracking tubes. In the device of the Burton and the Burton-Clark patents, a similar reflux was discharged into the shell still. What, if any, benefit is obtained in the Dubbs process, where the reflux travels through the heating tubes for the full length thereof, as compared with such an arrangement
351 998 as is provided in the Burton and Burton-Clark units?

A. In the arrangement provided by Dubbs, in which the reflux condensate is returned not to the vaporizing chamber but to the inlet of the cracking tubes, there are a number of important advantages.

In considering the solvent power of different hydrocarbons, it is generally recognized that materials of the same kind will dissolve each other more completely than will materials of different kinds; and the reflux condensate is a cracked product, it having already been

through the cracking coils and the vaporizing tubes before it was formed as a reflux condensate. It is therefore of similar chemical characteristics to other
352 cracked products. It is therefore an excellent solvent for cracked products, and for these unsaturated materials which are characteristic of such cracked products. Therefore, this reflux condensate, being returned to the inlet of the cracking tubes B, is an excellent solvent for other cracked materials which will form in the cracking tubes B. It therefore is an excellent solvent for these unsaturated polymer products, which may be formed from the heavy ends of the material charged to the cracking tubes B, and tends to hold these materials, which are unsaturated and of high molecular weight, in solution.

It therefore has this advantage of dissolving the unsaturated heavy polymers and carrying them out of the tubes, so that they will not form in high concentration on the tube walls and go to coke. So it helps, then, in removing the coke forming materials in cracking tubes B before they have a chance to go to coke.

352 998½ It has an additional benefit in tending to restrain the formation of these very heavy polymers, in that it dissolves these materials and thereby dilutes them in the liquid phase, which tends to slow down the rate of formation.

353 That can be explained, in the light of our present knowledge, by the fact that cracking is what is called a first order reaction. Cracking consists, first of all, of splitting a single molecule into smaller molecules of lower molecular weight and greater volatility. Then accompanying or following this primary reaction is a polymerization in which the unsaturated higher boiling product from the initial splitting reaction, being of an active nature, will combine with other similar unsaturated compounds. This polymerization is what is called a second order reaction, because it requires that two molecules of a somewhat similar type come into contact. Or, if we dissolve these molecules in the presence of reflux condensate, we then tend to hold these molecules further apart, thereby retarding the formation of these highly unsaturated, high molecular weight carbon forming materials.

Thirdly, the return of reflux condensate to the cracking coils enables the process to be conducted with a relatively low cracking per pass, and then separate out the insufficiently cracked materials in the reflux condensate, and return that material to the cracking
354 tubes B, where it may be further cracked.

If this reflux condensate were returned directly to the vaporizing tubes C or the vapor chamber, as in Burton and Clark, there would be much less opportunity for this material to crack, as it would be re-
354 999 turned to the same place from which it was previously vaporized and under the same conditions; so that it would vaporize very quickly from the vapor chamber, if it were returned directly to the vapor chamber. But being returned to the inlet of the cracking tubes, as in Dubbs, it is forced to traverse the entire length of the cracking tubes, where it is heated to a cracking temperature and where it can be more adequately cracked.

"Low cracking per pass" may be explained as follows:

Just for example, if the ultimate yield of pressure distillate is to be 50 percent of the charge oil, it would be necessary, without the return of this reflux condensate, to crack the charge oil to the extent of 50 percent as it went through the plant. But due to the fact that the reflux condensate is returned to the cracking tubes for further treatment, it is possible,
355 for example, to crack the material going through the plant only to the extent of producing 10 percent of pressure distillate, and then taking the reflux condensate and returning that again, so that the ultimate yield would still be 50 percent of the charge oil, although each time the combined feed goes through the plant it is cracked only to the extent of 10 percent. That would mean that the combined feed would be carrying about five times as much material as the fresh charge, because 10 percent of it each time is converted to pressure distillate, while 50 percent ultimately of the fresh feed is converted to the pressure distillate. That is a very important difference, because it means the cracking need not be carried so far in the cracking tubes B and in the vaporizing tubes C as to form these high molecular weight unsaturated

materials to such a degree as to deposit carbon.

355 1000 High pressure insofar as the action taking place in the cracking tubes is concerned, is important because it decreases the generation of vapors in the cracking tubes B and allows the oil to be heated to a higher temperature with less generation of vapors.

356 It also increases the density of the vapors which are generated, thereby holding the mixture of liquid and generated vapors in the cracking tubes B for a longer time, which increases the capacity of the plant. And furthermore, because the high pressure increases the density of the vapors, it makes the vapor more like the liquid and prevents the danger of separation of the vapors from the liquid in the cracking tubes.

High pressure in the cracking tubes B tends to make the liquid lighter. Because the high pressure tends to prevent the generation of vapors, it retains in the liquid the material which would otherwise be present as bubbles of vapor; and because the liquid contains these lower boiling materials, it has a lower viscosity and is generally lighter and more fluid. This is advantageous because it means that it will maintain its foamy condition more readily, and will pass out of the tubes at the same rate as the vapor.

The advantage of providing a large space in each of the runs on the coil C on each of the vaporizing tubes C above the non-volatilized oil is as follows:

In the vaporizing tube C the operation that takes place is the separation of vapor from liquid. And in the separation of vapor from liquid, there must be provided a surface of the liqiud from which the

357 1001 vapors may liberate themselves, and also a space above the liquid in which any droplets of liquid that may be entrained in the vapor can settle back into the liquid. So, for efficient operation or liberation of vapors, we must have a relatively large surface of the liquid and space above that surface.

I will now make reference to the portion of the Dubbs patent which describes the action which occurs in the vaporizing tubes C, including this space above the surface of the liquid. I have already read from the patent that C are the vaporizing tubes, and that the oil passed into the tubes C, which are only partly filled with oil; and as the oil passes through these tubes, there is liberation of vapors.

And again, on page 2, line 43, where it is stated that vaporization takes place in these tubes C.

358 The reference to the vapor space appears in the claims, particularly in claim 5, which describes,

"A continuous process for cracking hydrocarbons consisting in passing the same in a stream in an advancing direction from an inlet point to a discharge point separated and entirely disassociated from the inlet point, subjecting the material in the first stage of its travel to a cracking temperature while preventing substantial vaporization,"

That refers to the cracking tubes B—

"affording a vaporization space above the stream during the second stage of the travel thereof to said discharge point."

And that refers to the vaporizing tubes C, and clearly states that the vaporizing space exists above the liquid residue in the vaporizing tubes C.

359 1002 The reference to the vaporizing space in the description of the patent is page 1, beginning with line 78:

"Said oil is then passed into the tubes C which are only partially filled with the oil and as the oil passes through these tubes, there is a liberation of vapors from same—"

Therefore, there is provided, above the residue in the tubes C a space which is referred to as a vaporizing space.

I now refer to page 2 of the specification, the sentence beginning with line 40:

"The heated oil then passes to the 10-inch coils C which are maintained about half full of oil and wherein vaporization takes place."

That refers to this vaporization or liberation of vapors which takes place in the coil C.

Within the purview of this patent, there is a difference between the generation of vapors and the liberation of vapors.

360

The generation of vapors refers to the formation of bubbles of vapor within a liquid; while the liberation of vapors refers to the separation of vapors from liquid, as takes place when the turbulent condition is removed and the liquid has a chance to flow out, forming a surface from which the vapors may liberate or disengage themselves.

Referring to the action which occurred in the C tubes, this is like the action which I have defined, as liberation of the vapors. I do not find a similar action in the B tubes. Cracking occurs in that part of the
361 Dubbs apparatus designated B. Cracking also takes place in the vaporizing tubes C for the following reasons:

361 1003 The material reaches its highest temperature in the cracking tubes B, and the tubes B are referred to as the cracking tubes in the patent, page 1, line 52. The patent states, beginning line 71, page 1, in describing the process,

"Describing the operation of the process, the material to be treated is drawn from any suitable source by means of the jump J and discharge therefrom through line J^1 into and through tubes B and during the time they are passing through said tubes, they are subjected to sufficient heat to cause the desired amount of cracking."

In the tubes B the material is heated to the degree to cause the desired amount of cracking.

And then, at the bottom of the page, beginning line 108, the statement,

"The per cent, of vapors generated from the oil as it passes through the tubes C will depend on the amount of heat acquired by said oil while passing through the 4" coils."

Now, vapors can be generated from the oil as it passes through the tubes C only by a continuation of the cracking reaction, as once the vapors are liberated from the oil after it leaves the tubes B, there
362 is no opportunity for the oil to reach any higher temperature, and the pressure remains substantially constant. There is, therefore, cracking in the tubes B and cracking in the tubes C, with the statement that the cracking in the tubes B may be regulated by the amount of heat put into the oil while it is in the tubes B, and that the generation of vapors in the liquid in the tubes C will depend in turn upon the heat that the oil has received in passing through the cracking tubes B.

Insofar as the Dubbs patent is concerned, it is not of any importance what proportion of the total
362 1004 cracking takes place in the cracking tubes B and what proportion takes place in the vaporizing tubes C. The statement is made that the cracking can

be controlled by the conditions under which the oil is heated in the cracking tubes B.

363 I have heard the term "clean circulation" applied to the Dubbs process and I am familiar with its use in connection with the Dubbs process. I have heard it used quite generally. The Dubbs process warrants the application of that term for the following reasons:

"Clean circulation," I believe, refers to the circulation of a material which is put through a cleaning step each time it goes through the cycle, and the material which is circulated is the reflux condensate which passes through the cracking tubes B, the vaporizing tubes C, up through the partial condensing system, the slanting tubes E, G and G', and is then again returned to the inlet of the cracking tubes B, through the line F and F'. That is the only material which is circulated through the plant, and every time it goes around the cycle it is subjected to a cleaning step in the vaporizing tubes C. The reflux condensate which goes through the cycle is separated from the residue by this vapor liquid separating step in the tubes C, and none of the unvaporized residue is circulated with the reflux con-

364 densate. Therefore, because the material which is circulated has been cleaned up each time it goes around the cycle, the phrase "clean circulation" has been applied to this operation.

The essential features in this operation are that the reflux condensate be returned to the entrance end of the cracking tubes without containing any of the liquid residue from the vapor liquid separating step;

364 1005 second, that the condition in the cracking tubes B be that which I have described, including vapor generation but not vapor liberation, because if the liquid residue was to separate from the stream as it passed through the cracking coils B the benefit from this operation would be lost; and, third, the liquid residue from the vapor separating step in the vaporizing tubes C, which is the cleaning step to which I have referred, must be removed from the cycle and not returned to the cracking tubes B.

365 The final desired end product produced by the process practiced in the Dubbs patent is a pressure distillate. It is substantially identical to that produced in the Burton and Burton-Clark operation. Pressure distillate consists of the cracked product which has a

boiling range from about 80 degrees F. up to perhaps 500, more or less, degrees F. It includes the material which will constitute gasoline and some higher boiling material which will be recovered as pressure distillate bottoms.

The pressure distillate produced in these cracking operations is usually subsequently treated with acid or some other means to improve the color, stability and other properties of the finished gasoline. That material after treatment is then redistilled to recover the gasoline as a distillate, and the residue left behind of the higher boiling materials is the pressure distillate bottoms. Therefore, the final gasoline is the
366 one really sought for in operating a process of this sort. My basis for the view that I have just expressed is that the whole cracking art at the time of Burton, and, later, Dubbs was devoted almost exclusively
366 1006 to the production of gasoline. The demand for gasoline was increasing very rapidly and that was the problem of the petroleum refiner, to supply the demand for gasoline and still keep his production from crude oil in balance.

The patent in its example states that, on page 2, line 61, "The gravity of the distillate discharge from the water cooled condenser is about 52 to 56 Baume and in quantity is approximately somewhat more than half of the gas oil subjected to treatment.

367 The gravity of the distillate, 52 to 56 Baume, clearly defines a pressure distillate containing large percentages of gasoline, over 50 percent of gasoline, and is comparable to the pressure distillate produced in the Burton and the Burton-Clark operations.

The temperatures given of 750 to 860 degrees F. and the pressure of 100 pounds are also temperatures and pressures known at that time, suitable for the production of gasoline from oil. The statement at the first part of the patent, that he is trying to solve the carbon problem so that the apparatus can stay on-stream for a longer period of time, also indicates that he is contemplating the deep cracking to produce gasoline, as there was no real carbon problem when we were cracking simply to produce kerosene. There is no doubt but what this operation is a gasoline producing operation.

I will explain what I mean by deep cracking. If a

material is cracked very moderately, or shallow cracking, we do not produce in that cracking operation a satisfactory proportion of very volatile material,
367 1007 as is necessary for the production of gasoline. We only increase the volatility of the material to a limited degree. In that operation the cracking is
368 not severe enough to cause the extreme carbon problem which did become so important as soon as the industry tried to produce gasoline commercially by cracking.

I am familiar with the expression "mixed phase cracking." Mixed phase cracking indicates that the cracking takes place in a mixed phase where there is liquid and generated vapors, and with that classification the Dubbs patent is a mixed phase cracking operation. The end boiling point of the reflux which is produced in the operation of the Dubbs patent will depend upon the operating conditions. In the example given in the patent where the pressure is 100 pounds and the temperature from 750 to 860, and the charge is a gas oil, that end point would be probably about
369 850, possibly 900, and in other operations where different conditions exist that may be higher or it may be lower.

I think it would always be above 750. My idea is it will be 900 degrees, plus or minus. Of course when you say "end point" I am assuming you mean that which would be obtained in a vacuum distillation, because it is impossible to obtain these end points in the ordinary atmospheric laboratory distillation.

The true boiling point would make it perhaps a little higher than what I have said. The accumulation of carbon in the vaporizing tubes C would not present a hazard because these tubes are unheated. I think that is stated in the patent, page 1, line 29.

372 1008 At the present time the anti-knock value of a gasoline is referred to as its octane number. The octane number is the percent by volume of iso octane included in a blend of normal heptane which when tested under specified conditions in a specified motor in a laboratory has the same knocking characteristics as the fuel being tested.

373 In general the higher the octane number, the greater the anti-knock value of the fuel, and the lower the octane number the greater is the tendency of the fuel

to knock in an engine. There is some difference of opinion on the real importance of avoiding knocking or having gasoline which will avoid knocking. The automobile manufacturers insist that they want very high octane numbers so that they can build engines of high compression ratio and get high power and high efficiency from them, and in general those are the advantages to be obtained from high octane fuels if the engine is designed to take advantage of the high octane number.

374 The benzol value or benzol equivalent was a basis used about ten years ago for determining the anti-knock values of gasolines. The unfortunate thing about the benzol values was that we had one standard material, benzol, which was blended with another base material which was not standardized. Most of us used a straight run Pennsylvania gasoline as the other standard, but even straight run Pennsylvania gasoline isn't a too well standardized product, so that the benzol values that were in use up to about eight or ten years ago were not uniform throughout the country. But it was defined in very much the same way, that the benzol value was the per cent by volume of
374 1009 benzol in a blend with straight run Pennsylvania gasoline (or other product) which had the same knocking characteristics under the test conditions as the fuel being tested. A higher benzol value meant a higher anti-knock value.

375 The benzol values were not standard throughout the country. Up at the University of Michigan we did quite a bit of testing of that kind and, as I recall, zero benzol value on our scale at Michigan corresponded to about 40 octane number. Now, other laboratories would have a different comparison.

I am familiar with the Egloff patent in suit, copy of which is in evidence as PX 502.

PX 510 is a photographic enlargement of the drawing in Egloff patent 1,537,593. My understanding of the Egloff patent is as follows:

376 The object of this patent, which is for cracking to produce gasoline, is particularly as set forth on page 1, about line 15, "the object in the present instance being to subject the reflux condensate to different conditions of temperature or pressure or both than that to which the raw oil is subjected."

As Dubbs subjected his cycle material to a cleaning step each time it went through the cycle, Egloff has added to that a cleaning step for the charge material. Perhaps I can make that clear by referring to the drawing, where pump 8, shown at the lower central part of the drawing, is the pump which takes the charge material which, as given in the example by Egloff, is topped crude or heavy fuel oil, and forces that material through the coil 5 in the lower furnace, wherein it is heated to the desired temperatures. It is then
377 1010 passed through the valve 10 into the transfer line 9, going upward to the expansion chamber. On its way to the expansion chamber 12 it meets a stream of separately heated reflux condensate which comes through the valve 15 into the transfer line 9. The streams are combined in the transfer line 9 and enter the expansion chamber 12. In the expansion chamber 12 vaporization of both of these streams takes place and there is vaporized from the charge a material which passes upward out of the expansion chamber, through the line 19, which is a broken line but which carries these vapors to the bottom of the dephlegmator through valve 20. The dephlegmator is also shown broken and shows only the lower end and the upper end of a bubble tower or other type of reflux condenser. So that these vapors which are separated from the residue of the fuel oil or topped crude in the expansion chamber pass into the bottom of the dephlegmator, wherein these vapors, having boiling points above that
378 desired in the final product, are condensed in the partial condenser or dephlegmator and refluxed back to the bottom of the dephlegmator, from which they pass through the line 23, the valve 24, to pump 25. So that the material that is picked up by pump 25 and sent through the coil 6 in the uppermost furnace has all been through a cleaning up step in the expansion chamber, so that the residue from the vapor liquid separating step which occurs in the expansion chamber does not enter the coil 6. That residue from the vaporization which takes place in the expansion chamber 12 is withdrawn through line 17 and the valve 18 at the lower right-hand part of the expansion chamber. Then this material being heated to a tem-
378 1011 perature and under pressure conditions suitable for cracking in coil 6, is discharged into the trans-

fer line 9, as I have described, and that material undergoes a similar vapor liquid separation in the expansion chamber as I have described for the Dubbs patent, and also for the material that came in from the furnace 5. So that everything which—or, rather, all the material which is picked up by pump 25 and fed to the coil 6
379 has all been through this vapor liquid cleaning operation accomplished by the separation of the vapor from the liquid in the expansion chamber. The vapors which pass upward through the dephlegmator and are of the desired boiling range and are not condensed in the dephlegmator, pass over as a vapor through line 27 into the condenser 29, through the line 31 into the receiver 33, where the gas is separated from the liquid or pressure distillate, the gas being removed through line 38 and valve 40, and the liquid pressure distillate being removed through line 36 and the valve 37.

The essential parts of the equipment are clearly shown in the drawing and consist of the pump 8, the heating coil 5, a vaporizing or vapor liquid separating chamber, such as 12, the dephlegmator or partial condenser referred to as 21, the pump 25, and the high temperature high pressure coil 6, and the final condenser 29 and receiver 33.

The process is as I have described it and as given particularly in an example beginning the second column of the first page, line 85:

380 1012 "The process may be carried out as follows: "Fuel oil, as for example fuel oil from the Wayside Kansas field of say 25 degrees Baume"—

That would be a topped crude of about the same character I have shown you in the examples—

"may be heated to a temperature of say 700 degrees F., and subjected to a pressure of say 135 pounds in the heating coil 5, and delivered in substantially liquid phase through the insulated transfer line 9 to the expansion chamber 12. This expansion chamber may be maintained under a pressure of say 135 pounds. The reflux condensate may be pumped back by pump 25 to the heating coil 6, and there subjected to a pressure of 175 pounds and a temperature of say 770 degrees F. It is delivered in substantially liquid phase to the vapor chamber 12."

That being simply an example to indicate one operation that he may have in mind. He says:

"It will be thus seen that the reflux condensate is continuously subjected to recracking, but at different conditions of temperature, of pressure, or both, than that to which the raw oil is subjected."

The essentials of the conditions of operation are similar to those which I have described for the Dubbs process, and in addition the oil, the charge oil, as it
381 is pumped through coil 5 must be heated to such a degree that after it gets into the expansion chamber and is mixed with the heated oil from coil 6 there must be recovered from that oil, that charge oil, a substantial amount of condensate. If the oil that was charged through the coil 5 simply went into the expansion chamber and was all removed through
381 1013 line 17, valve 18, there would of course be no charged formed from that material to constitute the charge to the high pressure high temperature coil. Therefore, it is necessary of course that this material generate vapors and that these vapors be separated from the liquid in the expansion chamber, and as taught in the patent it is clearly intended that there will be cracking of this material that passes through coil 5 as it goes through the expansion chamber, thereby producing a greater amount of suitable charge material for the high pressure high temperature coil 6 than would be obtained if the quantity of vapor generated and separated from the liquid coming through coil 5 were simply that which would be produced by simple distillation.

382 The part of the specification which supports my statement that cracking occurs in coil 6 is on page 1, line 103: "It will be thus seen that the reflux condensate is continuously subjected to recracking, but at different conditions of temperature or pressure, or both, than that to which the raw oil is subjected."

The material which is fed to the coil 6 is similar to the combined feed of the Dubbs patent. The materials flowing from coils 5 and 6 also undergo cracking in the expansion chamber, producing some material that would boil in the pressure distillate range, also considerable material which would boil in the gas oil
383 range, which in addition to the material which is boiling in the gas oil range in the original charge would all be vaporized from the residue of that charge material in the expansion chamber.

383 1014 The gas oil which I just referred to which is produced in the expansion chamber from the material fed initially to coil 5 which is in effect the fresh feed portion of the combined feed which is fed to coil 6 is similar to this gas oil.

The pipe 17 is the line for withdrawing the residue from the expansion chamber, and this withdrawal is controlled by the valve 18, as stated at page 1, line 52:

"The expansion chamber 12 is provided with residue draw off pipe 17, having throttle valve 18."

The process carried out according to the teaching of the Egloff patent exhibits clean circulation as I have described it.

1065 1015 I understand the construction of the apparatus and the process practiced by defendant in this apparatus as set forth in the stipulation which is in evidence of defendant's operation, which stipulation has been copied into the record, commencing at page 138.

1066 PX 508 is a photographic reproduction with the exception of the color that has been added and the flap which has also been added, I should say.

I will now describe the apparatus and process of defendant's operation as shown on PX 508 and compare it with the Dubbs process.

1067 Referring to PX 508 with the flap up that we can see the entire operation of the plant, the reduced crude from the gasoline removal system is introduced at the upper left hand part of the exhibit by the pump shown to the lower right hand side of the low pressure furnace. This material is the residue which has been left from the straight run removal or distillation of gasoline from the crude oil. It is introduced into this furnace at a temperature of 540 degrees, which is the temperature at which this material is supplied to this cracking unit, and at a pressure of 260 pounds by this pump. It then passes through the coils of the low pressure furnace and is discharged at a temperature of 720 degrees F. into the transfer line from this furnace.

The transfer line to which I have just referred is colored green and shows the transfer of this material from this low pressure furnace into the lower part of the separator, which is the vertical vessel

1068 1016 marked "Separator" in the central part of the drawing.

As it enters this separator at the lower left hand corner of the separator it is mixed with the stream of material coming from the high pressure furnace, which stream is colored red (indicating).

And the two streams intermingle in the short section of the transfer line entering the lower left hand side of the separator. This stream colored red is at a higher temperature and serves to increase the temperature of this stream of topped crude coming from the low pressure furnace, which is colored green, with the result that this topped crude in the separator is heated to a temperature of about 805 degrees as indicated at the lower part of the separator. This is a
1069 cracking temperature and a higher temperature than that to which the oil was heated in the low pressure furnace.

The pressure in the vapor separator is 26 pounds, as indicated at the upper part of the separator. Under these conditions of temperature and pressure existing in the separator, a large part of this reduced crude is vaporized and passes off from the top of the separator as indicated in the green line shown leaving the top of the separator.

Also in this separator cracking occurs in this vapor separator, the total extent of which is stated on the exhibit in the square shown to the left of the vapor separator, wherein it is stated that about 6,000 pounds per day of gas and 105 barrels of gasoline per day and 20 barrels per day of pressure distillate bottoms and 120 barrels per day of gas oil are produced
1069 1017 in the vapor separator by cracking. That is a statement of the total chacking which has been stipulated as occurring in the separator. By that I mean the products of cracking which occurred in the
1070 vapor separator.

Most of this gas oil and the other materials, so stipulated as produced by cracking in the separator, are produced by the cracking of this topped crude as it is in the separator. So that we have leaving the top of the separator in the vapor state material which has been vaporized out of the topped crude by simple vaporization and in addition material which has been vaporized out of the topped crude which has been produced by cracking.

These materials pass up out through the top of the

separator in a vapor state free from any significant entrainment, and pass through a heat exchange system, which we may as well skip for the time being as heat exchange system is simply a device to conserve heat, in which the heat in these vapors leaving the top of the separator is transferred in part to the crude oil in order to supply the heat necessary to vaporize out of the crude oil the straight run gasoline. It is not part of the cracking process but is simply there as a means of conserving heat.

071 These vapors, after they pass through the heat exchangers, parficularly the first heat exchanger, pass on from the lower part of the first heat exchanger through the streams as indicated by the green line, and enter the bottom part of the bubble tower or dephlegmator at the lower lefthand side.

071 1018 These vapors which have been produced from the topped crude by simple distillation and by cracking, pass upward through the bubble tower in counter current contact on the various bubble plates with down flowing liquid. That is, the vapors pass upward through the tower and are brought into intimate contact on each of the bubble plates with a stream of down flowing liquid.

That is a well known principle of counter current dephlegmation or rectification as it is called in the industry. As indicated on the stipulated drawing, the pressure in this bubble tower is 24 pounds, and the temperature at the lower part is about 595 degrees. As the vapors pass upward through the bubble tower they are colled by the down flowing liquid and when they have reached the central part of the bubble tower

072 their temperature has been reduced to 475 degrees. At this point the vapors are removed from the tower and pass through another heat exchanger, which has no particular function in the cracking operation but again is a means of conserving heat, and also to decrease the load on the upper part of the bubble tower.

The vapors, after they pass through the heat exchanger, then enter the upper section of the bubble tower and any liquid which has been condensed from the vapor in the heat exchanger, pass out through the bottom of the heat exchanger as indicated by the

green line and is returned to the bottom part of the bubble tower.

As the vapors pass upward through the upper section of the bubble tower they are cooled to a tem-
1073 perature of about 375 degrees, as indicated at the top of the bubble tower.

By the time these vapors have been cooled to
1073 1019 that temperature, all of the insufficiently cracked material that has come from the vapor separator and the gas oil which has been vaporized out of the topped crude oil in the separator, have been condensed to a liquid and that liquid flows down the bubble tower and collects at the bottom of the bubble tower where it is withdrawn by the pump.

The sufficiently cracked material which is desired to be included in the pressure distillate, passes on upward out of the top of the bubble tower and over to the condenser.

It is frequently referred to as the final condenser to distinguish it from the partial condenser or bubble tower. These vapors pass over into the condenser wherein the pressure distillate is condensed to a liquid. From the bottom part of the condenser the uncondensable gas and the condensed pressure distillate flow into what is called the gas separator. In the gas separator the uncondensable gas separates
1074 from the condensed pressure distillate and the gas passes upward out of the gas separator through the back pressure valve to the gas recovery system and out from the process.

The condensed pressure distillate is removed from the bottom of the gas separator through the line marked "Pressure Distillate to Storage". An additional quantity of pressure distillate is removed from the gas separator by another pump and pumped to the top of the bubble tower to provide the cooling or the reflux necessary to maintain the desired temperature at the top of the bubble tower. This pressure distillate which is returned to the top of the bubble tower in this manner simply cycles around to the top
1074 1020 of the bubble tower where it is vaporized and then returns back to the condenser, and operates in a closed cycle serving the purpose of cooling the top of the bubble tower.

Cooling in the bubble tower is effected as follows:
The pressure distillate is in the liquid state as it is pumped to the top of the bubble tower. At the tem-
1075 perature and pressure conditions existing at the top of the bubble tower the pressure distillate is vaporized and absorbs a quantity of heat equivalent to its latent heat of vaporization. That heat is absorbed from the vapors which are at the top of the bubble tower and thereby condenses out of the vapors the higher boiling material which passes on down through the column and is finally collected at the bottom of the bubble tower as the reflux condensate. This reflux condensate which is collected at the bottom of the bubble tower, consists of the gas oil which has been distilled out of the reduced crude; and also of insufficiently cracked material which has been introduced into this stream from the separator.

The gas oil which has been topped out of the topped crude or reduced crude in the vaporization which occurred in the separator, constitutes the fresh feed which is present in this reflux condensate at the bottom of the bubble tower, and from the bottom of the bubble tower we have a read and green line; the green
1076 line representing the fresh feed or this gas oil which has been distilled out of the crude in the separator, while the red line represents the reflux condensate or insufficiently cracked material which was introduced into the stream from the high pressure furnace
1076 1021 at the bottom of the vapor separator.

That corresponds to what I have referred to as the combined feed.

The combined feed here is represented by the combined green line and the red line, the green line corresponding to the fresh feed and the red line corresponding to what is called reflux condensate in these cracking operations.

In this particular operation some of this material is removed at this point through the line marked "gas oil" and sold as a product or worked up into a finished product, but most of it is picked up by the large pump referred to usually as the hot oil pump, because it handles this oil which is heated to a temperature of about 600 degrees Fahrenheit. And there the pressure of this oil is increased from about 24 pounds per square inch to about 660 pounds per

square inch, which is indicated at the entrance end of the high pressure furnace. Into this stream
1077 1022 is also introduced as additional fresh feed some heavy naphtha charge and which also constitutes part of the fresh feed.

The combined feed composed of the material topped out of the reduced crude in the separator, plus that heavy naphtha, along with the reflux condensate from the bottom of the bubble tower, is then introduced to the high pressure furnace under a pressure of about 660 pounds as shown on the stipulated drawing.

This high pressure furnace or cracking furnace heats the combined feed to the temperatures as indicated on the stipulated drawing, or PX 508. After this material has passed through the first bank of tubes it has been heated to about 665 degrees, as indicated. It then enters the uppermost bank in the so-called convection section referred to as the second bank of tubes, where it receives more heat and is then at a temperature of about 725 degrees F. It then enters the third bank of tubes, or the roof tubes, so-called because they are directly under the roof of
1078 the furnace, and after passing through these tubes it reaches a temperature of about 910 degrees as it leaves the third bank of tubes, and at this point there has been some vapor generation to the extent of about 10 per cent by weight; as stated in the
1078 1023 stipulated drawing here, about 90 per cent by weight is liquid.

Also in the stipulation, but not shown on the drawing, is a distillation of material removed from this point which indicates that approximately one-third of the gasoline which is made in the operation has been produced by cracking which has occurred in this stream up to this point.

After removal from the roof tubes, where it is at a temperature of 910 degrees F., that material enters the fourth bank in the convection section, and then the fifth bank. As it is removed from the fifth bank into the transfer line, the temperature is 940 degrees F. and the pressure is 500 pounds per square inch. And in the transfer line, after the material leaves the cracking furnace, there is about 15 per cent by weight liquid or about 5 per cent of the entire volume

of this stream is occupied by the liquid, so that in the
1079 transfer line the vapor generation is about 85 per cent by weight. And this material in the transfer line is represented by a red color, because that represents only the material coming from the high pressure cracking furnace.

It then goes through a so-called pressure release valve where the pressure is reduced from about 500 pounds to something less than that, and the stream from the high pressure furnace intermingles with the stream from the low pressure furnace, and the two streams pass into the vapor separator, at which point the pressure has been reduced to about 26 pounds.

1079 1024 That completes the cycle of the material through the plant and as stated on the stipulated drawing the cracking occurring in this cracking furnace or the high pressure furnace is about 1,755 barrels per day of gasoline produced in the high pressure furnace by cracking and reforming. The language used there, "By cracking and reforming", means that 1,755 barrels of gasoline so produced in this furnace comes in part from material which originally boiled within the gasoline range as introduced
1080 from the so-called heavy naphtha; but that is the amount of gasoline produced by cracking and reforming in the high pressure furnace, and also shown in the stipulated drawing is the amount of material produced by cracking in the separator.

These are the two places in the operation where cracking takes place as indicated on the stipulated drawing.

Now in the vapor separator, we have the separation of vapors from liquid, and as stated in the square to the left of the vapor separator, the quantity of material in the vapor separator in the liquid state corresponds to about 16 barrels of liquid. This liquid does not exist as a quiet pool of liquid but is a rather foamy mass because the vapors and liquid are all introduced at the lower part of the separator so that the vapor has to pass upward through the liquid in order to liberate itself from the liquid which keeps this condition as a foamy mass as stated in the stipulation, but the liquid in this foamy mass corresponds to about 16 barrels.

1081 1025 In addition to that it has been stipulated there is about one barrel of petroleum oil present as vapor in this foam, so that foam consists of 16 barrels of liquid and one barrel of liquid petroleum in the vapor state. Above the level of the foam it has been stipulated there are three barrels of vapor. That means that there are three barrels of liquid petroleum present as vapor above the foam. So that the vapor separator is filled with a foamy mass in the bottom part and with vapor in the upper part.

The level of this foam is indicated by the properties of the material removed from the various try cocks.

These try cocks are valves placed in sampling lines at the side of the vapor separator which serve the purpose of removing material from the vapor separator. The material so removed through these try cocks is passed through a water cooled condenser so that the material is cooled and condensed to prevent the flashing of this material at these high temperatures if it comes in contact with air, and these samples so re-
1082 moved have been tested and the gravity of these samples are indicated on the stipulated drawing. For example, the gravity for the No. 2 try cock sample is indicated as 12.2 gravity. The gravity of the sample taken from No. 3 try cock, is indicated at 22.3. And the gravity of the material removed from the No. 4 try cock, is 28. gravity.

The gravity of the material leaving the top of the vapor separator, with the exception of the un-
1082 1026 condensable gas, is approximately 28 degrees A. P. I., which is substantially the same as that indicated for the material removed from try cock 4, which indicates that at the level of try cock 4 we are removing material which is vapor of the same kind as is passing out of the top of the separator; while at try cock 3 the lower gravity of 22.3 indicates the material there is of different composition. And as we go down further to try cock 2 the gravity is 12.2, still heavier, and indicates a still heavier composition of material. That means that the foam has broken somewhere about the level of No. 3 try cock and at the level of the No. 4 we have a sample of the material in vapor state of the same character as that pass-
1083 ing out of the top of the separator. At the level of try cock 3 we have material which contains some of

the liquid residue which is removed from the bottom of the separator, and at try cock No. 2 we have a greater proportion of this liquid residue in the sample. The gravity of the liquid residue which is removed from the bottom of the separator can be found by referring to the square or tabulated data in the lower right hand corner where the gravity of the fuel oil is given as 10.1.

Now by means of these gravity determinations we can compute the approximate amount of vapor and liquid which is in the foam at the levels of try cocks 2 and 3. The yields from the operation are summarized in the table at the lower right hand corner of this stipulated drawing, which also gives the gravity of these various streams.

1084 1027 The reduced crude charge is the first item in that table, and that is the reduced crude which is charged to the low pressure furnace at the upper left-hand corner. It has a gravity of 25.8, and there are 1,230,000 pounds plus charge per day or 3,911 barrels as shown.

The additional charge to the cracking unit is the heavy naphtha which is introduced into the discharge or hot oil pump as I have described. This heavy naphtha has a gravity of 45.2, and is charged to the extent of something over 79,000 pounds per day, as shown in the exhibit, or about 283 barrels. It constitutes about 6.1 per cent of the charge by weight or 6.7 by liquid volume; so that the total charge to this operation is 4,194 barrels per day and mostly reduced crude with some heavy naphtha.

The total material charged to the high pressure furnace, that is the combined feed entering the high pressure or cracking furnace, amounts to 2,221,660 pounds per day or 6,940 barrels; and this material has a gravity of 23.1, which is even lower than that of the reduced crude charged to the low pressure furnace.

1085 The pressure distillate is the material which is removed from the gas separator and which contains the gasoline which is the ultimate desired product.

This is produced to the extent of 2,224 barrels per day, which amounts to 53 per cent of the liquid

1085 1028 volume of the total charge, or 45.2 per cent of the total weight of the charge, the percentage expressed on a weight base. Its gravity is 54.6.

The next line refers to gas oil which is removed from the bottom of the bubble tower through the line marked "Gas Oil" as shown. This has a gravity of 22.2, and is removed to the extent of about 160 barrels per day, which is something less than 4 percent of the charge.

Then the fuel oil or residue is the material removed from the bottom of the vapor separator, which amounts to about 1620 barrels per day or 38.7 per cent by liquid volume of the charge, or 43.2 per cent by weight of the charge, and has a gravity of 10.1, as I have stated.

The total liquid products obtained from the oper-
1086 ation amount to 4,004 barrels per day, and the difference of 190 barrels per day represents gas and the losses as obtained by the difference.

1086 1029 Referring to the operation which takes place in the part I have called the separator, I find that therein the vapors separate themselves from liquid oil and pass from the top of the separator to a dephlegmator. At the outlet of the roof tubes ap-
1087 proximately 75 to 80 percent of the volume of the total stream would be occupied by liquid, so that the volume occupied by the generated vapors would be about 20 to 25 percent of the total stream.

At this point the vapors would exist as generated vapors or bubbles within the stream. As stated in the stipulated drawing, in the transfer line at the outlet of the high temperature furnace about 5 percent of the stream volume is occupied by the liquid, or about 95 percent of the stream volume is occupied by these bubbles of vapor, so that the entire mass passes through the transfer line as a foamy mass. At that point the generated vapors had not liberated themselves from the non-volatilized oil. I will now
1088 elaborate on the character of the foam which exists in the transfer line. It is a foamy mass in which the vapors are present as bubbles within this film of liquid which surrounds the bubbles of vapor, and that the entire mass is moving through the line with a uniform average velocity; that is, that the liquid is not being left behind on the walls to travel along as a trickle along the bottom of the tubes, while the vapors rush on ahead, but the vapor and liquid pass on at the same average velocity.

The liquid is present in a continuous phase, surrounding the bubbles of vapor.

I am informed that the separator that I have
1088 1030 referred to is lagged to prevent heat losses by radiation. But I have never inspected the plant.

1089 The oil which is left behind in the separator as a residue from the vapor-liquid separation and which collects in the bottom of the vapor separator is removed continuously through the line leading from the bottom of the separator through the cooler, through the valves, as shown, through the pipe marked "Fuel oil to storage," and is removed from the separator to a storage tank.

The fuel oil would be sold as commercial fuel. It might be used by locomotives or other industrial uses for fuel oil.

The reflux ratio defined as the ratio of cracked material to uncracked material, which is in the com-
1090 bined feed, to the high pressure or cracking furnace, is about 2 to 1, specifically 1.95. That means there is about twice as much cracked material in the feed to the high pressure furnace as there is uncracked material.

If that is defined a little differently, we would get a slightly smaller value for that. If it is defined as the ratio of the recycled material through the high pressure cracking furnace to the fresh feed or charge to the high pressure furnace, that value is about 1.8; so that the reflux ratio is about 2 to 1.

The function the reflux performs in the high temperature furnace is first of all it enables the operation to be conducted in such a manner that the cracking per pass or the depth to which the material is cracked when it passes once through the furnace can be relatively low, about 16 or 19 percent, say, and yet the total production of cracked products can be approximately three times that, because the material which is insufficiently cracked is returned to the high pressure, high temperature furnace for
1091 1031 further treatment. So the return of the reflux condensate in a high proportion such as this first of all enables the operation to be conducted at a relatively low cracking per pass.

Secondly, it serves as a solvent for the high molecular weight unsaturated cracked material which

is produced in the high pressure, high temperature furnace, and because this material is dissolved, because this high molecular weight material is dissolved in this reflux material, it retards the polymerization of these high molecular weight unsaturated materials to carbonaceous material called coke.

Thirdly, it serves as a solvent for this material and, being present in this proportion, enables this material to be carried out in solution in the reflux, so that the high molecular unsaturated material is carried out of the high pressure cracking furnace along with the generated vapors, and there is no chance for this material to stick to the tubes and form the carbonaceous deposits by separating from the rest of the stream.

The term asphaltines has been used to describe
1092 these high molecular weight unsaturated materials which on additional heating would have a tendency to form rapidly carbonaceous material.

I will now explain more fully what is meant by cracking "per pass."

1093 The cracking per pass is the percent of material produced each time the combined feed goes through the high pressure cracking furnace. For example, if the material going through the high temperature high pressure furnace contains no gasoline and
1093 1032 gas when it goes into the furnace, and contains, let us say, 20 percent of gas and gasoline as it comes out of the furnace, we say the cracking per pass is 20 percent.

Then this material that comes out of the furnace goes through the vapor separator and the bubble tower. In the vapor separator these high boiling high molecular weight unsaturated materials which have been produced in the cracking operation in the furnace are removed from the bottom of the separator as liquid residue; and insufficiently cracked material, along with the material which has been cracked to the desired extent, pass out of the top of the vapor separator in a vapor state and enter the bottom of the bubble tower. In the bubble tower the insuf-
1094 ficiently cracked material is condensed out of the vapors and collects at the bottom of the bubble tower. This insufficiently cracked material from the bottom of the bubble tower is then refluxed or returned or

recycled to the high pressure cracking furnace, so that the next time it goes through the cracking furnace it will in turn produce some of the material boiling in the range desired in the final product or in the pressure distillate.

Now, if it were necessary to accomplish all of the cracking desired in a single pass, the yield from the operation would be extremely small, being, let us say, about 20 percent if we were to maintain equally satisfactory conditions in the furnace. If we wanted to obtain greater yields, let us say 40 percent, we would then have to crack twice as severely in the cracking furnace; but in heating for the longer
1094 1033 time necessary to produce, let us say 40 percent cracking per pass, these high molecular weight unsaturated materials would be subjected to this cracking condition for a longer time and by that time
1095 they would be more likely to form carbonaceous deposits and coke on the tubes. So by having a relatively low cracking per pass in combination with the return of the reflux condensate or insufficiently cracked material, the operator is enabled to get a high yield of gasoline with very satisfactory conditions in his furnace, so that he gets the desirable operating conditions accompanying a low cracking per pass with a high yield.

I think that is what you had in mind when you asked me what I meant by cracking per pass and its advantages.

1097 The stream from the high temperature furnace continues to crack in the separator.

I will now compare defendant's process with that of the Dubbs patent in suit. If the flap is put down on PX 508, we then have the operation which is equivalent to that of the Dubbs patent as consisting of the following elements and operations: The gas oil which is vaporized out of the reduced crude in the separator collects at the bottom of the bubble tower and constitutes the fresh feed for the operation comparable to the fresh feed in Dubbs. This fresh feed is forced by the large pump, which we may call the hot oil pump, into the cracking furnace, the tubes in which furnace correspond to the cracking tubes in the Dubbs patent. Cracking occurs in these tubes

with vapor generation but without the separation of the generated vapors from the liquid.

1097 1034 The outlet from the cracking tubes or the cracking furnace is conveyed through a transfer line to a vapor separator wherein vaporization takes 1098 place. That is, the separation of the generated vapors from the liquid takes place in this separator in a manner equivalent to that in which it takes place in the vaporizing tubes of the Dubbs patent.

In addition to the separation of the generated vapors in the separator, there is further generation of vapors from this stream passing from the high pressure high temperature furnace into the vapor separator, just as there is in the Dubbs patent.

The liquid residue from this vapor separating step in the separator is removed from the bottom of the separator. and not returned to the cracking tubes. The separated vapors pass upwards out from the top of the vapor separator, and are subjected to reflux condensation in the bubble tower. The reflux condensate collects at the bottom of the bubble tower and is returned to the cracking tubes with the fresh feed, in the form of a combined feed.

The vapors which contain the material boiling in the desired range for the final product, and which are not refluxed in the dephlegmator or bubble tower, pass overhead through a vapor line into a condenser, 1099 and from the condenser into a separator.

The apparatus as so shown with the flap down contains the same elements as disclosed in the Dubbs patent, and they operate with the same functions.

The reflux performs substantially the same function in the defendant's process as it does in the proc-1099 1035 ess of the Dubbs patent in suit. As to the condition of the liquid vapor in the transfer line, functionally considered, there is no difference between the defendant's process and the process of the Dubbs patent.

Q. Assuming that the Court construes the phrase, "substantial vaporization prevented", as found in the Dubbs patent in suit 1,392,629, in referring to the conditions obtaining in the cracking tubes B of that patent, to exclude only liberated vapors or the libera-1100 tion of vapors from the non-volatilized oil, and does

not exclude the generation of vapors, would you find that, in the practice of the process disclosed in the Dubbs patent, the oil is continuously passed in a stream through a series of tubes in a cracking zone where the oil is heated to a cracking temperature but substantial vaporization is prevented?

A. Yes.

Q. Under the same assumption, would you find that in the operation of defendant's process?

A. Yes.

Q. Under the same assumptions, would you find that in the operation of the Dubbs process the oil is passed in a stream and in the first stage of its travel it is subjected to a cracking temperature while preventing substantial vaporization, and that in a second stage there is afforded or provided a vaporizing space above the stream?

A. Yes.

Q. And would you find that in the operation of
01 defendant's process?

01 1036 A. Yes.

In comparing defendant's operation with that described in the Egloff patent, we put the flap up which shows and includes the low pressure furnace. The charge to the operation is introduced, as I have described, through the pump at the lower righthand side of the low pressure furnace, which corresponds to the pump shown in the Egloff patent which is numbered 8. The charged material then passes through the low pressure furnace and is discharged at a temperature of 720. This low pressure furnace corresponds to the coil marked 5 in the Egloff patent. The material leaving this low pressure furnace passes through the transfer line colored green and joins the transfer from the high pressure or cracking furnace, following the pressure release valve in the same way
02 as that material is transferred from the low temperature furnace coil 5 through the line 9 and meeting the material transferred from the high temperature cracking furnace.

The combined stream then in the defendant's operation passes into the vapor separator in much the same way as the combined stream passes into the expansion chamber in the Egloff patent, the difference

here being that the vapor separator in defendant's operation is set vertically, while in the Egloff patent the expansion chamber is shown in a horizontal position. They are both insulated vessels but unheated.

From the bottom of the vapor separator in defendant's operation is removed the residue which is not returned to any of the coils, in the same way as the residue is removed from the bottom of the expansion chamber in Egloff through line 17 and valve 18.

1102 1037 In this expansion chamber in Egloff and in the separator of defendant's operation, the material which is to be charged to the cracking tubes undergoes a screening action in which the non-volatilized high boiling material is separated from the vapors. The vapors liberated in the expansion chamber in Egloff or the separator in defendant's operation pass

1103 upwards from the top of the separating chamber to the bottom of a dephlegmator or bubble tower. In the dephlegmator or bubble tower the insufficiently cracked material from the high pressure or cracking furnace and also the gas oil and other material distilled out of the fresh charge are refluxed and collect in the bottom of the dephlegmator or bubble tower. The gas oil so collected in the bottom of the dephlegmator, and which has been vaporized out of the topped crude which constitutes the charge, there constitutes the fresh feed to the high pressure cracking furnace. This material is transferred through lines 23 and by means of pump 25 in the Egloff patent, which corresponds to the line from the bottom of the bubble tower and the large or hot oil pump in defendant's operation.

This material is then sent through an independent furnace wherein it is heated to a higher temperature and pressure than is the fresh charge in the low pressure furnace. The high pressure furnace in defendant's operation, wherein a major part of the cracking takes place, corresponds to the high temperature furnace or coil 6 of the Egloff patent. The transfer material discharged from this high temperature furnace mingles with the transfer material from the low pressure furnace in the manner I have described, and the cracked products from the high

pressure furnace in defendant's operation or
1104 1038 coil 6 in Egloff, pass into the separating chamber wherein is separated out a liquid residue containing the high boiling unsaturated material which pass upward out of the expansion chamber or separator so that the product from the high temperature furnace and also the product from the low pressure furnace each undergo a screening action in the separator wherein these high molecular weight unsaturated non-volatilized materials are removed from the stream.

1105 The vapors feed from this residue containing the material of the desired boiling range for the final product and the insufficiently cracked material then pass upward from the vapor separator and are subject to reflux condensation, as I have described, in the bubble tower or dephlegmator. The material having the desired boiling range is not condensed in the bubble tower or dephlegmator but passes overhead, in both Egloff and in defendant's operation, through the vapor line which is numbered 27 in Egloff, down to the water cooled condenser, which is numbered 29 in Egloff and simply marked "Condenser" on the stipulated drawing, into a gas separator in defendant's operation, or so-called receiver in Egloff. In this receiver or gas separator the uncondensed gases separate themselves from the liquid and pass out from the top of the receiver or separator through a back pressure valve, which is marked 40 in the Egloff patent, and the pressure distillate containing the material of the desired boiling range for the final product, gasoline, is removed from the bottom of the receiver in Egloff through the line 36 and the
1105 1039 valve 37, or shown in defendant's operation in PX 508 through the line marked pressure distillate to storage.

1106 In defendant's operation in the low temperature coil the oil reaches the cracking temperature. It is heated above 700 degrees and I believe that 700 degrees is usually considered a cracking temperature. It does not necessarily follow, however, I think to make that clear, that there is any significant cracking to gasoline, but it has been heated to what was called a cracking temperature.

When that oil meets the oil in the transfer line or the oil from the high temperature coil, it is there heated to a higher temperature of about 805 degrees, which of course is an active cracking temperature, and at that temperature significant cracking does take place.

Q. Should the Court construe the phrase "preventing substantial vaporization," as that occurs in the Dubbs patent, in reference to the conditions obtaining in the cracking tubes B, to exclude a condition in which there are vapors in the tubes or vapors are generated in these tubes irrespective of whether
1107 or not they liberate themselves from the non-volatilized oil, would you find that that would also exclude the illustrative run or the conditions which would be obtained in making that run which is found in the Dubbs patent commencing on page 2, line 35.

A. Yes, it would.

1107 1040 Based on PX 597 which is the record of a run made of the Dubbs unit at Independence, Kansas, in July 1919, I will estimate the yield of gasoline.

1108 The percent yield of gasoline as I have estimated it is 32.7 percent. This was done by computing the gasoline produced over each three-hour period, which begins on page 2-2 which is where these data are first shown.

At 9 P. M. we find that there has been produced from 6 P. M. to 9 P. M. 246 gallons of distillate the gravity of which was 48.5, and it contained 51¼ percent at 400 degrees. By multiplying the 248 gallons for that three-hour period by the 51¼ percent, which is the laboratory test on that distillate, I have put in a figure of 126 gallons, being the gasoline produced.

Doing that for each of the three-hour periods beginning with 6 P. M. on July 19th, when the plant apparently went on-stream, to the end of the run, I have determined by that method the number of gallons of gasoline which were produced, and dividing that by the total material charged during the same period I find there is 32.7 percent of gasoline so produced.

Referring to the exhibit and to the conditions of operation which it shows, and to the diagram PX

519 which illustrates the unit in which the run was made, this unit having 10 4-inch 20-foot tubes discharging into a series of 4 10-inch 20-foot tubes or vaporizing chambers from which the residue was discharged and not returned to the system, I will state my opinion as follows:

1041 (a) Vapor generation would occur in the cracking tubes;

(b) Cracking would occur in the cracking tubes;

(c) There would be no liberation of vapors in the cracking tubes;

(d) The condition of the material in the cracking tubes would be with bubbles of generated vapor within the liquid and at the outlet of the cracking tubes would be what we call a foamy mass;

(e) Cracking occurs in the vapor chamber or vaporizing tubes;

(f) The vapors which pass to the dephlegmator liberate themselves from the non-volatilized oil in the vaporizing tubes.

Referring to PX 583 which is a summary of the operating conditions and results of a run carried on at Roxana unit No. 2 in a system as shown by PX 581, in which there are 50 4-inch tubes 30 feet long, making a heating and cracking coil of 1500 feet, discharging into a vaporizing chamber 10 feet by 30 feet in which the level of oil was raised as carbon accumulated from a few feet from the bottom at the beginning of the run to a few feet from the top; and assuming a reflux ratio anywhere betwen three parts of reflux to one part of raw oil and five parts of reflux to one part of raw oil, I will state my opinion as follows:

(a) Vapor generation would occur in the cracking tubes;

(b) Cracking would occur in the cracking tubes;

(c) Vapors do not liberate themselves in the cracking tubes from the non-volatilized oil;

1042 (d) The condition in the heating or cracking tubes is that of generated vapors in the liquid, or what might be called a foamy mass;

(e) Cracking occurs in the vaporizing chamber;

(f) The vapors which pass to the dephlegmator liberate themselves from the non-volatilized oil in the vaporizing chamber.

Referring to PX 584, which is a summary of the operating conditions and results of a run carried out in 1925 at Arkansas City in a system as shown by PX 581, in which there were 50 4-inch tubes 30 feet long, making a total coil of 1500 feet discharging
1115 into a 10-foot by 10-foot vaporizing chamber, and
1116 assuming that as the run proceeded and as the coke accumulated in the vaporizing chamber the level of the oil in the vaporizing chamber rose from about one-third from the bottom to a few feet from the top, and assuming also a reflux ratio of anywhere between three parts of reflux to one part of raw oil and five parts of reflux to one part of raw oil, I will state my opinion as follows:

1117 (a) Vapor generation would occur in the cracking tubes;

(b) Cracking would occur in the cracking tubes;

(c) The generated vapors do not liberate themselves from the non-volatilized oil in the cracking tubes;

(d) The condition of the material in the heating or cracking tubes would be that of bubbles of generated vapor within the liquid, the entire mass being what would be called a foamy mass;

1117 1043 (e) Cracking would occur in the vaporizing chamber;

(f) The vapors which pass to the dephlegmator would liberate themselves from the non-volatilized oil in the vaporizing chamber.

I will assume a set-up like that shown in PX 577 and further assume as follows:

1118 (1) Cracking tubes as shown in said exhibit made up of four parallel banks of 4-inch external diameter tubes, each bank being 240 feet long;

(2) A raw oil feed of 235 barrels per day of 35 degree Baume gas oil, charged through the dephlegmator;

(3) A reflux ratio of anywhere between 3 to 1 and 5 to 1;

(4) An oil transfer temperature of 790 to 820 degrees F.;

(5) A yield of residue of 40 per cent, of 25-29 Baume gravity, based on the charge;

(6) A combined feed temperature between 700 and 760 degrees F.;

(7) That the 16-inch external diameter vaporizing tubes in said exhibit were insulated to prevent heat radiation losses, and that a large vapor liberating surface was provided in these tubes with the vapor space thereabove and that these tubes were from one-thidr to one-half full, and that a pressure of approximately 125 pounds was provided in the system by the generated vapors;

(8) That the yield of Navy Specification Gasoline was 28 percent based on the raw oil; and

(9) That the residue was withdrawn and not re-
1119 turned to the system.

1119 1044 Based on these assumptions, I will state my opinion as follows:

(a) Vapor generation would occur in the cracking tubes;

(b) Cracking would occur in the cracking tubes;

(c) The vapors generated in the tubes would not liberate themselves in the cracking tubes from the non-volatilized oil;

1120 (d) The condition in the heating or cracking tubes is that of generated vapors as bubbles in the liquid or non-volatilized oil, the whole material being in the state of what may be called a foamy mass;

(e) Cracking would occur in the vaporizing tubes: and

(f) The vapors which pass to the dephlegmator would liberate themselves from the non-volatilized oil in the vaporizing chamber or vaporizing tubes.

Referring to PX 523, and making the following assumptions:

(1) That the single heating coil shown was made up of 33 tubes each approximately 30 feet long of 4-inch external diameter, making a total tube length of 90 feet;

(2) Fresh feed was supplied to the still at the rate of about 300 barrels per day, the feed being 35 Baume gas oil and that in the operation of the still a reflux ratio of anywhere between 3 to 1 and 5 to 1 was maintained;

(3) That the oil transfer temperature was 790
1121 to 820 degrees F.;

(4) That the vaporizing chamber shown had a length of about 30 feet and an internal diameter of

4 feet and was insulated to prevent heat radiation losses, and that in the operation it was main-
1121 1045 tained about one-third to one-half full of liquid oil;

(5) That in the operation of the set-up on the run in question the on-stream period was about eight and one-half days, and the operation produced a Navy Gasoline yield of 37 percent based on the raw oil charge;

(6) A pressure of about 170 pounds was maintained throughout the system;

(7) That the residuum was withdrawn and no part of it returned to the system,"

I will state my opinion as follows:

1122 (a) Vapor generation would occur in the cracking tubes;

(b) Cracking would occur in the cracking tubes;

(c) The vapors as are generated in the tubes would not liberate themselves in the tubes from the non-volatilized oil therein;

(d) The condition in the heating or cracking tubes would be with bubbles of generated vapor within the liquid, the whole mass taking on the character of a foamy mass;

(e) Cracking would occur in the vaporizing chamber or expansion chamber;

1123 (f) The vapors which passed to the dephlegmator would liberate themselves from the non-volatilized oil in the vaporizing chamber.

1123 1046 Referring to the same setup to which I last made reference, and making the following assumptions:

(1) That the fresh feed consisted of 24 gravity fuel oil and it amounted to 490 barrels per day, and that the reflux ratio was any place between 3 to 1 and 5 to 1;

(2) That the pressure maintained in the system throughout the system was approximately 119 pounds, the transfer temperature was approximately 840 to 870 degrees F., that the run produced 35 percent based on the fresh feed of Navy gasoline; and that otherwise the conditions were as stated in the preceding question,

I will give the following opinion:

(a) Vapor generation would occur in the cracking tubes;

(b) Cracking would occur in the cracking tubes;

(c) Such vapors as would be generated in the
1124 cracking tubes would not liberate themselves in the tubes from the non-volatilized oil;

(d) The condition in the heating or cracking tubes would be that of bubbles of vapor within the oil, which might be described as a foamy mass;

(e) Cracking would occur in the vaporizing chamber;

(f) The vapors which passed to the dephlegmator would liberate themselves from the non-volatilized oil in the vaporizing or expansion chamber.

Referring to PX 524 showing the Roxana set-up and assuming that the coil there shown was of 4-inch outside diameter tubes, the total length of the tubes approximately 1,020 feet, that the vaporizing
1124 1047 chamber was 10 by 10 feet and was insulated, and during the operation was maintained about half full of oil; assume the feed consisted of 35 Baume gravity gas oil and that it approximated 300 barrels per day, and that the reflux ratio was anywhere be-
1125 tween 3 to 1 and 5 to 1; assume that the pressure maintained on the system was about 145 pounds with a transfer temperature of 860 degrees F. and with a combined feed temperature entering the 4-inch tubes between 720 and 750 degrees F., and that the yield was about 38 per cent Navy gasoline based on the raw oil; and assuming that the residue was withdrawn from the system and no part was returned, I will state my opinion as follows:

1126 (a) Vapor generation would occur in the cracking tubes;

(b) Cracking would occur in the cracking tubes;

(c) The vapors generated in the tubes would not liberate themselves in the tubes from the non-volatilized oil;

(d) In the heating or cracking tubes the vapors would be present in the form of bubbles within the liquid, what may be called a foamy mass;

(e) Cracking would occur in the vaporizing chamber;

(f) The vapors which passed to the dephlegmator

would liberate themselves from the non-volatilized oil in the vaporizing chamber.

Based on the same assumptions, except that instead of gas oil fuel oil was the fresh charge to the system, the rate of feed was 490 barrels per day, the pressure was 100 pounds, the transfer temperature was 880 degrees F., and the operation was con-
1127 1048 ducted on the same plant, I will state my opinion as follows:

(a) Vapor generation would occur in the cracking tubes;

(b) Cracking would occur in the cracking tubes;

(c) The vapors generated in the cracking tubes would not liberate themselves in the tubes from the non-volatilized oil;

(d) The condition in the heating or cracking tubes would be with the generated vapors present as bubbles within the liquid, the whole being regarded as a foamy mass;

(e) Cracking would occur in the vaporizing chamber; and

(f) The vapors which passed to the dephlegmator would liberate themselves from the non-volatilized oil in the vaporizing chamber.

1128 Referring to PX 581, which is the model of the 500-barrel Dubbs standard unit, in which there are 50 4-inch tubes each 30 feet long, discharging into an insulated vaporizing chamber 10 feet in diameter by 10 feet high maintained about half full of liquid oil. Assuming a run of about 500 barrels per day of raw oil and a reflux ratio of anywhere from 3 to 1 to 5 to 1 of reflux, and that the transfer temperature was from 860 to 890 degrees Fahrenheit and the pressure from 150 to 190 pounds; assume that the charge was gas oil having a gravity of 32 to 35 degrees Baume and that the yield of Navy Specification Gasoline based on the charge was approximately 40 percent, and that the residue was withdrawn during the run from the system and not returned, I will state my opinion as follows:

1129 1049 (a) Vapor generation would occur in the cracking tubes;

(b) Cracking would occur in the cracking tubes;

1130 (c) Vapors generated in the tubes would not

liberate themselves in the tubes from the non-volatilized oil;

(d) The condition in the heating or cracking tubes in respect to the vapors generated and the non-volatilized oil would be the generated vapors present as bubbles within the oil, the whole mass being regarded as a foamy mass;

(e) Cracking would occur in the vaporizing chamber; and

(f) The vapors which passed to the dephlegmator would liberate themselves from the non-volatilized oil in the vaporizing chamber.

My answer would be the same if we consider the same set-up but instead of gas oil, fuel oil or topped crude was used as the fresh charge, and that the pressure on the system was 100 to 150 pounds and the yield of Navy gasoline was between 30 to 45 percent based on the charge, and the temperature about the same.

1132 Q. I asked you before recess your opinion in reference to conditions in an operation which was based on PX 583, and in which I asked you to assume certain operating conditions, among others, that there were 50 four-inch tubes 30 feet long constituting the heating or cracking coil, and that the vaporizing chamber was 10 feet by 30 feet. Would your answer to the question be any different were you to substitute 62 tubes for the 50 tubes in the cracking or heating coil?

A. No, that would make no difference in those answers.

1133 1050 Q. I also asked you your opinion as to certain conditions based on the operation of a plant such as that exemplified by PX 581, in which I asked you to assume that there were 50 four-inch tubes, 30 feet long, and that the vaporizing chamber was 10 feet in diameter by 10 feet high. Would your answer be the same if you were to substitute 62 tubes for the 50 tubes in the heating coil and for the vaporizing chamber one 10 feet in diameter and any height from 10 to 40 feet?

A. The answer would be the same.

I testified on behalf of the plaintiff in the case of *Universal* v. *Root Refining Company* in which case the accused apparatus was a Winkler-Koch still. This suit was brought in the District of Delaware.

In that suit I described the operation of the defendant's process.

(A chart showing the comparison of the Root operation is introduced in evidence as PX 598.)

PX 598 is the same as Exhibit 508 with the exception that the figures in red ink have been added indicating other operating conditions.

1134 The other operating conditions are those which were observed during the inter-partes tests and inspection made on the Root Refining Company's operation, and also some of the statements made in that case regarding the conditions at the outlet of the high pressure cracking furnace. These are put on for purposes of comparing the different conditions.

1135 1051 Q. Now, referring to these different conditions as indicated on PX 598, how, if at all, do they affect the conditions which obtain in the transfer line or in the high temperature heating coils in the respect to the liquid vapor condition in this coil and in the transfer line, and the function which the liquid oil performs as compared with the description you have given of defendant's process at bar as exemplified, for instance, in the PX 508?

A. The function of the liquid in the material leaving the high pressure cracking furnace is the same in each case. The differences are those indicated on Exhibit 598 in that in the Root operation the temperature in the transfer line was 900 degrees F. instead of 940 degrees F. as in the Globe operations as shown in the stipulated drawing. The pressure was the same, being 500 pounds in each case. The percent by weight of liquid in the Root operation was about 45 percent, where it is about 15 percent in the Globe operation as set forth in the stipulated drawing.

1136 The function of the liquid is the same in each case. As to the condition of the liquid and vapor in the transfer line, the conditions are the same in the sense that there would be a foamy mass in each case. The only differences are that a greater percentage of the volume of the stream is occupied by the vapor bubbles in the Globe operation than was the case in the Root operation.

In each operation I have described the function performed by the liquid in the foamy mass as it passes

through the transfer line in each operation. The liquid acts as a solvent for the high molecular weight unsaturated material and holds this material in
1136 1052 solution and carries it out in solution in this liquid in the foamy mass.

1137 In the Root operation the liquid is in continuous phase. There is no difference in the function performed by the reflux in the Root operation from that performed by the reflux in defendant's operation. The functional difference produced by the lower temperature to which the oil was heated as it left the roof tubes in the Root operation as compared with defendant's operation is that it probably would indicate that there would be less vapor generation at that point in the Root operation than there was in the Globe, and if the throughput was the same and the furnace was substantially the same, it might indicate less cracking in that stream at that point.

In defendant's operation I would say that the pressure in the transfer line from the low temperature
1138 furnace at the outlet of the roof tubes would be 75 to 100 pounds. In the Root operation it was about 92 pounds.

In defendant's operation at bar the oil temperature leaving the low temperature furnace was 720 degrees F. and in the Root operation it was 798 degrees F. I will now indicate whether or not this makes any difference.

The higher temperature in the Root operation being about 78 degrees higher, is a much more active cracking temperature and there was some gasoline produced, as testified to in the Root case, in the low pressure furnace. Both the 720 and the 798 are
1138 1053 cracking temperatures but the 720 is a low cracking temperature while the 798 is a more active cracking temperature.

1139 Referring to the temperature and pressure conditions in the Root operation and defendant's operation at bar, as indicated in PX 598, I will state the effect of the differences in temperature and pressure in the separator.

The temperature in the separator is uniformly lower in the Root operation than in the Globe operation, being approximately 15 degrees lower in the Root at the bottom of the separator, and about 12

degrees lower at the top. This lower temperature in the Root operation would mean that the cracking would take place less rapidly in the Root operation in the separator than it would be in the Globe. So that there would be indicated that we might expect to find more cracking in the separator in the Globe operation than was found in the Root due to the higher temperature.

As to the differences in temperature and pressure
1140 in the bubble tower, the temperatures in the bubble tower in the Root operation are somewhat higher, the pressure is slightly higher. I don't think that has any significant difference. It simply means that there was less heat extracted in the heat exchanger in the Root operation than in the Globe or the operating conditions were somewhat different.

Q. Did these differences which are indicated on PX 598 between the conditions obtaining in the Root operation as compared with the conditions obtaining in defendant's operation, affect the similarities or differences between these two operations as com-
1140 1054 pared with the Dubbs process?

A. No.

1141 The effect of the high superatmospheric pressure in the heating tubes of the process in the Dubbs patent in suit and the process of the defendant is that the high pressure tends to decrease the extent of the vapor generation in the tubes at the indicated temperature; it increases the density of the generated vapors in the liquid and brings the density of the vapors more nearly equal to that of the liquid, thereby increasing the time that the material is in the tubes and increasing the capacity of the plant. It also, by making the density of the vapors more nearly like those of the liquids, tends to suppress any possible vapor separation that might possibly take place at lower pressures.

Q. Do the differences indicated on Plaintiff's Exhibit 598 make the Root operation exemplify in a greater or lesser degree the process of the Egloff patent than that as exemplified in defendant's operation?

A. No, I think they make no difference.

In the Globe operation the pressure on the separator is 26 pounds, and on the bubble tower it is 24 pounds.
1142 The fresh oil charged in the Root operation and the

products resulting from the practice of the Root process are substantially the same as in defendant's operation at bar.

1055 *Cross-Examination by Mr. Theiss.*

1142 Assuming that the word "vaporization" means solely generation, and that it does not include the
1143 separation of the vapors from the liquid, then in my opinion it probably cannot be said that the oil in the heating tubes was heated to a cracking temperature but without substantial vaporization in all the runs as to which I gave opinions in my direct testimony.

I am not quite sure what you would mean in that sense when you say "substantial vaporization." "Substantial" is a relative term. But I should say probably that term would not be applied in all of those cases.

I do not know how I define substantial generation of vapors. It all depends on what I mean.

"Substantial liberation of vapors" is something that is rather sharply defined.

1144 Without substantial vaporization would mean that conditions are similar to those when there is no separation of the vapors from the liquid.

"Without substantial separation" just means that the material flowing through the tubes has the properties as though there were no liberation of vapors, therefore there would be no substantial liberation of the vapors.

Q. What is the function of the word "substantial" in that phrase?

1144 1056 A. Well, there might be some technical discussion, I suppose, between technical men as to exactly at what point the liberation took place or exactly what point you went from a foam into a spray.

Q. Could you have insubstantial liberation, that is, liberation that was not substantial?

1145 A. Well, that is what I am saying, there might be some technical argument about that but I do not think it has any practical significance. I think practically we may say that the character of the material is a foamy mass in which there is no substantial separation or that it is the opposite of that.

Q. Well then, there is no function for the word "substantial" before the word "liberation"?

A. I think there is, because, as I tell you, technical men might get into a discussion or an argument as to exactly where the separation begins or exactly where separation takes place; but if there is no substantial separation I think that means that the properties of that mass of material are substantially the same as though there were no separation. I think that is what that language means.

Q. Can you tell me just when you would have insubstantial separation?

A. I say that technical men might get into an argument as to exactly where separation began to take place. Now there might be the condition where you are approaching the point where separation takes place when you have a foamy mass passing
1146 along the tube and in some cases that liquid
1146 1057 may not be continuous phase momentarily.

Q. How would a practical operator know where in the tube it took place and where it did not take place?

A. Well, he would start with conditions where vapor generation was relatively low, let's say 50 per cent, and then if he kept on increasing the vapor generation, getting more and more vapor generation and the operation continued in about that same way, no break or no sudden change in the results, I should think that would be an indication to him that he was still operating in substantially the same way. Then if he continued to get more and more generation, if other conditions came about, a change in conditions of operation and a change in the results at that point, there would then be a change in the condition in the furnace, and we might then say that there was substantial separation.

1147 Q. In other words he would have to experiment to find out where that point was?

A. Well, unless he had scientific knowledge and he might estimate it.

Q. Well, do you think a man skilled in the art as of 1919 had that scientific knowledge so that he would know?

A. I doubt if any of them had in 1919 where they could predict exactly where that break would come.

The Court: Just to clear up, I suppose when there is separation, there is separation, there isn't any such thing as a dividing line between substantial and unsubstantial separation? Would you mean that separation substantially or insubstantially would be in the amount or what? Separation would be sep-
1147 1058 aration or it would not, wouldn't it?

A. I do not think it is quite as sharp as that. There is a sort of twilight zone where perhaps scien-
1148 tists may be on a ground for debate. To make my position clear on whether there can be insubstantial separation, suppose we go over to the separator on this plant. Now there is a place in the separator where the liberation takes place, because we have in the upper part of the separator, vapors, and you have in the bottom, liquid. Now that zone where liberation and separation takes place, is not too sharply defined, and there is sort of a surface there or a zone wherein these vapors become liberated from the liquid. In
1149 the coil you would get substantial liberation by the same conditions as you would get it in the separator where the velocity conditions and the volume ratios between the liquid and vapor become such that the liquid can no longer hold the vapor in bubbles, and that vapor then separates from the liquid. As soon as you reach that point, as soon as you get vapors liberated they do not sharply liberate from the liquid. There will be little parts where you have discontinuous films of liquid or droplets of liquid. It is a zone, it is a kind of range in there. We cannot say positively that at a certain point there is no liberation and right at exactly a certain point it is all liberated. There is sort of a twilight zone in there
1150 which is a rather narrow zone but it is present. In any one of the runs concerning which I have given my opinion at R. 1109, on points A to F,—the obvious change to make in order that vapors formed in the heating or cracking tubes would liberate them-
1150 1059 selves from the liquid in these heating and cracking tubes would be to have a very low velocity so that the flow of material through the tubes is no longer in the form of a turbulent mass but approaches the conditions as described in the patent for the G tubes in which the liquid would flow along the bottom part of the tubes and the vapors would be

liberated from that liquid and flow along the space above the liquid in the tubes. What that velocity would be in the heating or cracking tubes is hard to say but it certainly would be, I should think, somewhat under a foot per second anyway; somewhere in
1151 there. You could not get any closer separation—it depends upon the properties of the vapors and the liquid. If the vapor approaches the density of the liquid, why then it has less tendency to liberate or separate. At the conditions in the Dubbs patent of 100 pounds I think liberation would be at some velocity under a foot a second. How much under, I don't know. As to operations using higher pressure, the higher the pressure, everything else being equal, the lower the velocity at which separation would occur. In other words, an increase in pressure tends to decrease the tendency of the vapors to separate from the liquid, everything else being equal.

1152 I have stated that in the Dubbs process vapors were generated in the B tubes and I have deliberately drawn a distinction between the generation of vapors and their presence mixed up with the liquid or oil, on the one hand, and the liberation of vapors from the liquid surface on the other, because the patent does the same thing.

1153 Ordinarily we use the term "vapor pressure"
1153 1060 to represent the tendency of a liquid to generate vapors or to pass off as a vapor. We usually do not refer to the pressure of the vapor as
1154 vapor pressure, at least I do not. The vapor pressure is the pressure which must be put on a liquid
1155 to just prevent that liquid from generating vapor. When vapors are generated, vapor bubbles tend to rise to the surface due to the buoyant action. The
1156 vapors are lighter than the liquid and they rise to the surface. But vapor generation will depend on the pressure on the liquid and the temperature. As soon as vapors are formed in a liquid the partial pressure of the components in the bubbles of vapor
1157 are then affected. When vapors are formed in liquid and before these vapors escape from the liquid body, heat is consumed in the transformation of the liquid into vapor bubbles. That is the latent heat required to transform the liquid from the liquid state into

the vapor state, and has been called latent heat of
1158 vaporization for many years. When vapor bubbles form in a liquid, the two phases, namely, vapor and liquid, are present. By the phrase "generation of vapors" which I have used repeatedly in my direct examination, I mean the change of state from liquid to vapor. That is, when vapors are generated, a portion of the liquid is "changed into vapors." The term "vaporization", standing alone by itself, might
1159, easily be interpreted to include vapor generation, and vapor generation and vapor liberation. That is, I mean I believe the term "vaporization" has been used in many cases designate what I am calling "vapor generation." It has not always been used only that way scientifically; it has been used both ways. The term vaporization has been used and is used concurrently to mean that you cause material to
1159 1061 pass off as a vapor. You see, vaporization takes place in the separator, vaporization takes place in the still. It is used that way very commonly, and it is also used by technical men to indicate the generation of vapors. It is one of the words that has a rather indefinite meaning, and its precise meaning can be determined only in the way it is used. I don't think the word "vaporization", in scientific books and in literature and in physics, from time immemorial, has always been defined as the
1160 generation of vapors. I think it "has been used for that purpose, and rightly so." I do not think it has been exclusively defined that way in physics and chemistry. I think I could find lots of places in physics or chemistry where it has been defined to mean both generation and liberation. I can't think of one now, but when we vaporize anything in a still, that vaporization is the common word used to express the action that takes place in the still; and in that still we have the generation and the separation of the vapors.

Q. Do you know of any instance where it has been used, except for the specialized definition that you
1161 are now giving to the Dubbs patent, where vaporization, the word "vaporization" has been used to mean anything else but vapor generation in defining vapors formed in the coil?

A. Well, the thing that comes to my mind first of

all is the description of the gyro process where
1161 1062 they had vaporizing tubes, and that is exactly what they meant in those vaporizing tubes, that they separated the vapor from the liquid, and conducted a dry vapor from the vaporizing tubes over to the cracking tubes. It just came to my mind now. There are perhaps other cases like that.

In those vaporizing tubes in the gyro process, they heated the material to get as nearly complete vaporization as possible, and they left behind in those tubes the small percentage which was not vaporized. There was a small percentage that was not vaporized but I don't know how much of a per cent. They
1162 used that term "vaporization" to mean the passing off as a vapor without carrying with it any liquid, and I think that is a very proper use of the word, and it is clearly the only meaning which we can give to the term in the Dubbs patent.

Referring to an article in the Industrial and Engineering Chemistry, "Laboratory Cracking Data as a Basis for Plant Design", by Richard L. Huntington and myself, on page 706 of this article, column 2, under the heading, "Analysis of Pipe Still Furnace Operation", I say, "This called for an analysis of the pressure drops through several sections of the pipe still. According to the flow formula for fluids, given by McAdams (16) for turbulent flow in straight pipes", and then I give the formula:

1163 "Starting with the oil entering the convection section, the velocity at the end of this section was assumed to be 12.85 feet per second. Run 31
1063 (Table II) shots that the specific volume is not
1163 changing rapidly with time. By interpolation a value of 0.0245 cubic foot per pound was selected for the 715° F. temperature. Since the specific volume at 570° F. was 0.022, according to the corrected specific gravity of 0.72 at that temperature, very little vaporization had evidently taken place at 730° F. and 300 pounds per square inch." As used in that text, and that is applied to a pipe still furnace, I clearly indicate vapor generation by that use of the word "vaporization." There I have referred to the vapor formed in a pipe in which the oil was in a turbulent flow as vaporization. I think that is a proper

use of the word. It can be used either way, but in the Dubbs patent it is very clearly used and defined in the patent to mean a separation of the vapor from the
1164 liquid. I think that the word "vaporization" might be interpreted in the Dubbs patent to mean vapor separation only. Offhand I don't know of any other place that it is so used except in the Dubbs patent; it might have been used so in other places, I would not be surprised. It certainly, in the Dubbs patent, must include vapor liberation; and in many of the dictionary definitions in common usage, it also includes vapor liberation. And I think the term "vaporization" can be used and is used to, on the one hand, mean vapor generation, and on the other hand to mean the generation and the separation of the vapors.

1176 I am teaching school at Michigan. In my college classes and in making talks before scientific
1064 bodies, I do not always say generation of va-
1176 pors as distinguished from vapor liberation.
1177 They would usually know from the context. We have many words in the English language which, standing alone, are not clear. In my opinion vaporization is not limited solely to vapor generation.

1181 Q. Mr. Brown, will you answer this question: Among scientific men of this country does the word "vaporization" mean vapor generation or the transformation of liquid into vapor?

Mr. Hall: Only; do you mean?

The Witness: Do you mean that it has no other meaning than that?

Mr. Thiess: Q. That is the meaning, the only meaning, that scientific men give to that word.

A. No, I cannot agree to that. That is a meaning
1182 which is given to the word. The reason that vapors, when formed in a body of liquid, tend to rise upward and liberate from liquid surface is because the vapors are lighter than the liquid due to the bouyant action we have discussed. Gravity is a component of it. It is due to the buoyancy of the bubbles of vapor in
1183 the liquid. Heat has something to do with the separation or liberation from the surface of vapors formed in the body of the liquid. The temperature of the liquid and the temperatures of the vapors determine the properties, and their properties in turn

determine the rate at which it is liberated. The
1183 1065 temperature of the liquid and the temperature of the vapors are factors which determine the rate at which the vapors will be liberated. It affects the properties of the liquid and the properties of the vapor and the rate at which these bubbles of vapor are
1184 liberated depends upon the properties of the liquid and the properties of the vapor. I can't tell you exactly how much effect it has. The properties of the liquid and the properties of the vapor are of considerable importance in determining the rate at which the bubbles of vapor are liberated. Sometimes the liquid may have such properties that the bubbles of vapor are not liberated even though you give them a very long time. The temperature is one of the things which determines the properties of the liquid and the properties of the vapors. As to instances in which vapors are not liberated, we have these foams which
1185 exist for a long time. The properties of the liquid and the properties of the vapor are the factors which determine the rate of liberation. If the pressures are different that is another factor which determines the properties of the liquid and the vapor. The effect
1186 that pressure has on the liberation of vapors is that it also changes the properties of the liquid and the vapor and therefore it changes the rate of liberation of the vapors. Pressure and temperature both affect
1187 the properties of the liquid and the properties of the liquid control the rate of liberation of the vapors from the liquid. The generations of the vapors are affected and are controlled substantially by temperature and pressure. That is not true of liberations; there
1187 1066 are other factors which control the liberation of vapors. Turning to the Dubbs patent in suit, Dubbs teaches the maintenance of pressure on the oil undergoing treatment by regulation of the valve H.
1188 This pressure is maintained in the system by throttling the valve in the line from which the gases and vapors escape, as shown in the drawing. This means that the pressure in the C tubes is substantially the same as the outlet of the B tubes. The patent says on page 1 beginning with line 78, page 1. "Said oil is then passed into the tubes C which are only par-
1189 tially filled with the oil and as the oil passes through these tubes, there is a liberation of vapors from same

and which vapors pass up through the vapor tubes D." These vapors are not liberated substantially as rapidly as formed. According to the statements made in the Dubbs patent, to which I have referred, the vapors are generated or formed over in the B tubes, at least a good part of them, and they are not liberated until they get into the C tubes; then after they are liberated in the C tubes in the manner I have just read from the patent they then pass up through the vapor tubes D. Since the pressure in C and B is substantially the same you get some vapor generation in both the B tubes and in the C tubes. And vapors are generated in the C tubes as a result of cracking.

Q. These vapors, as they are generated in the C tubes, are liberated as fast as they are formed, are they not?

A. Well, they are liberated very quickly.

1190 1067 Q. Now, the purpose which Dubbs has in maintaining full still pressure on the C tubes is to prevent vaporization of the oil in these tubes at a temperature below the cracking temperature, is it not?

A. I don't know that he quite stated it that way but I think that would be one of the objects, perhaps. I don't know. There is no limitation or statement of that kind in the patent, is there?

Q. Well, isn't it true that Dubbs wished to keep this oil in the C tubes at a temperature sufficiently high so that the liquid oil would be cracked in these tubes?

A. Yes, I think he definitely teaches cracking in the C tubes.

Q. It would be necessary to keep the pressure on that oil so that it would stay there in liquid form and could be cracked in the C tubes, isn't that true?

A. Yes, depending upon the temperature and the properties of the oil, and so forth.

Q. Well, taking the oil and the temperature and pressure conditions as taught in the patent?

A. Yes, he wants to keep a pressure on the mate-
1191 rial in the C tubes. All the heat that the oil receives in the Dubbs patent is imparted to the oil in the B tubes.

In the C tubes there is no increase in temperature.

There might be a small decrease in pressure due
1191 1068 to the friction losses as shown here. You wouldn't have any real decreases in pressure between the B and C tubes. Dubb's patent teaches, page 1, column 2, lines 107 to 112, that the per cent of vapors generated from the oil as it passes through
1192 the tubes C will depend on the amount of heat acquired by said oil while passing through the 4-inch coils. Therefore it is true that this per cent of vapors generated from the oil in the C tubes will be vapors generated by reason of the formation of these vapors in the cracking process as it occurs in these C tubes. I would like to state that a little more definitely, perhaps, that the vapors generated from the oil as the oil passes through the C tubes will depend upon a cracking reaction occurring in that oil as it passes through the C tubes. Now on page 2, line 43, Dubbs states that what occurs in the C tubes is vaporization.

Q. If vaporization, regardless of its cause, was the only thing desired by Dubbs in the C tubes, he could achieve it much better by greatly lowering the pressure in the C tubes below that which he has in the B tubes, isn't that true?

A. No.

Q. Why not?

1193 A. Because what he means by "vaporization" is the separation. If he meant that he wanted to convert the liquid into a vapor, if that was his object, that of course could be done very nicely by dropping the pressure, but that specifically is not what he is teaching by "vaporization" in the patent. He
1193 1069 is teaching that in the C tubes you get the liberation of the vapors from the liquid. That would not be helped at all by an appreciable decrease in pressure.

Q. If according to your statement that "vaporization" means both generation and liberation, wouldn't he effect that very materially by a reduction in pressure?

A. I don't think that is what he meant by the term "vaporization."

Q. Well, what do you think he meant by the term?

A. I think he means by the term "vaporization" the complete separation of the vapors from the liquid,

and his process that he defines as "vaporization" hasn't taken place until there is a liquid residue left and the vapors have passed off as vapors.

1194 Q. Well, now, let us get together on that. Is it your understanding that Dubbs uses the word "vaporization" to mean solely vapor liberation?

A. Primarily, yes, but he may—as I told you before I wasn't quite sure of it—he may possibly include in the term "vaporization" the generation of vapors that may take place while the separation is taking place.

Q. You are not certain whether he means that?

A. Well, in some places it looks as though he might mean that, but it is clear in my mind that you must have this separation step. You must have that step in order to meet Dubbs' definition of the term "vaporization."

1194 1070 It is perfectly clear that by "vaporization" he means the separation. That is what he means, that you must have the separation of the vapor from the liquid in order to accomplish vaporization.

Q. It is not clear whether he means both generation and separation?

A. He does not mean generation by "vaporiza-
1195 tion." That is specifically excluded. To have vaporization he must in all cases have the separation step. Now, I believe that that is what it is limited to. My interpretation is that the word "vaporization" is limited to that separation step.

Q. As used by Dubbs?

A. I believe so, yes. In my interpretation of the Dubbs patent the principle involved and its operation would not be altered if the pressure were reduced between the B and C tubes. It is my view that a pressure reduction between B and C, so that the C
1196 tubes would be subjected to less pressure than the B tubes would still be the same process and the parts would have the same function, and the same results would be obtained, but he does not teach the necessity nor disclose any means in his apparatus for having that decrease in pressure. Now, if the reflux from the dephlegmator in the Dubbs process of the patent in suit were returned to the C tubes instead of the inlet of the B tubes, there would be no circu-

lation at all through the B tubes. I wouldn't consider that clean circulation. I said there was no
1197 1071 circulation. If reflux were returned directly to the C tubes I think it would lower the temperature of the oil in these tubes, whereas by returning the reflux to the inlet of the B tubes Dubbs fulfills his object in imparting the cracking heat to all the material in the B tubes, assuming that there is the same quantity of fresh feed heated to the same temperature but with the reflux returned to the C tubes instead of to the B tubes.

Q. Whenever you would return reflux to the C tubes you would lower the temperature, would you not?

A. No. You can change lots of other conditions. That is what I wanted to be clear on. But assuming
1198 the same amount of fresh feed—heated to the same temperature—and the reflux returned to the C tubes, that temperature would then be lowered. By returning reflux to the inlet of the B tubes Dubbs fulfills his object of imparting the cracking heat to all of the material in the B tubes. The saving of heat is not the only advantage that accrues in returning the reflux to the inlet of the B tubes rather than returning it to the C tubes. I have tried to outline the
1199 other advantages a number of times. One is making it practical to operate at a low cracking per pass and still obtain high yields. Two, the solvent action of the reflux has two advantages. It retards the formation of the carbonaceous material by dissolving the high molecular weight unsaturated material, thereby decreasing the concentration of this material and preventing it from going to carbon as quickly; and then a second advantage, because it is dis-
1199 1072 solved in this material and the whole material is carried through the B tubes as a form with the same velocity, this carbon-forming material is carried out of the B tubes and not allowed to stay behind and form carbon.

Suppose we took the reflux and instead of returning it directly to the B tubes we passed it into the charging tank in which charging oil was kept, and the mixture of charge and reflux was maintained, and that was returned to the inlet of the B tubes, I think you would have all the advantages that I have

just enumerated. I think that is substantially one of
1200 these optional methods of operating that Dubbs has described which is not a preferred method and not the method that was used in developing the process, but they are described in the patent beginning line 6, page 2:

"For instance, the reflux distillates may be returned to the heating coils B directly or indirectly, part of them direct and part of them indirect. For instance, instead of returning the reflux condensate direct to the tubes marked B by means of line F', the same may be discharged into a tank marked L through line L' by opening the valve H6 which otherwise would remain closed and closing the valve H5 on line F' or part of the condensate may be returned directly back to the tubes B through line F' by regulating the opening of valve H5 and the rest discharged to tank L through line L' by regulating the opening of valve H6. Tank L may be maintained under pressure or not and it may contain the raw material that is being treated or contain wholly the reflux distillate and from this tank the contents of same are fed to the tubes B through line M into pump J and from there discharged into line J'.

"It will be noted that the reflux condensate in all cases is trapped off from the vapor lines in such
1201 manner as to prevent their returning direct to the vaporizing tubes C."

1205 1073 Q. Well, now, do you know what the reflux ratio of this Dubbs patent is from the patent itself?

A. Do you mean in these operations?

Q. From the patent itself.

1206 A. Why, it might be three or four to one, or something of that nature.

Q. How do you get that?

A. Do you mean how do I estimate that?

Q. Yes.

A. Well, from my experience and my study of the patent.

Q. Where is the teaching in the patent that gives you that reflux ratio?

A. The example.

Q. Will you please point out how you get it from that example?

A. Well, from my experience and the study of this example, the temperatures given and the pressures given, it seems to me that the operation conducted in this particular apparatus with the 860 degrees transfer temperature at 100 pounds would correspond with a fresh feed of perhaps 20 to 25 barrels of gas oil per day and a total through-put of about 80 to possibly 100 barrels a day through the heating coils B. That is the way I think this example would
1207 operate in this equipment. I think I know what a once through operation is.

Q. We are going to operate this Dubbs process or this Dubbs apparatus as shown in the patent
1207 1074 as a once through process, collecting the reflux in a tank.

A. Then you are going to operate with the valve H5 closed and also valve H6. What are you going to do with that? Run that into tank L?

Q. The valve? I haven't got H5.

A. H5 is in the line F.

Q. I am not concerned with the tank at all, with this particular tank L. The reflux comes down this line F, does it not?

A. That is right.

Q. Referring to the model?

A. That is right.

Q. I am going to draw that reflux off to a tank in the yard.

A. You are going to take it away from the plant?

Q. From the operation.

A. Yes.

Q. Run it to a tank in the yard near the process.
1208 A. All right.

Q. Then I am going to mix the charging stock with that reflux.

The Court: Do you mean the fresh feed?

Mr. Thiess: Yes, the same feed that Dubbs charges to his operation in his patent, 34 to 36 gas oil. I am going to mix that with that reflux in the same proportions as the reflux ratio you have just mentioned, and I am going to feed it through the Dubbs operation and recycle it.

A. What do you mean, through the Dubbs operation now?

Q. Through the Dubbs apparatus.
1208 1075 A. Operated as disclosed in the patent?
Q. No, operated as a once through process.
A. All right. Now, you are going to operate this apparatus the same way the second time as you did the first time?
Q. Yes, but instead of that I am going to use the combination feed of reflux and charging stock.
A. That is not what Dubbs teaches.
Q. Well, that is a hypothetical operation I am putting up to you.
1209 The Court: He asked if that should be operated in that way would the result be any different.
The Witness: Yes, there would be some difference.
Mr. Thiess: Q. What would be the difference?
A. Because you are not producing the same reflux condensate. It is not going back through the coils in the same way. That isn't what Dubbs has described.
Q. I am asking you, would you have all the benefits you have outlined, this solvent theory and all these other theories you have outlined?
A. What do you do? If I understand you—
Q. Can you answer that question?
A. I still don't quite understand this operation. See if I have got it right.
Q. All right.
A. You take gas oil, put gas oil through the coils B, is that right?
1209 1076 Q. Right.
A. Then you draw off residue, draw off reflux and pressure distillate and run them all into tanks, is that right?
Q. Right.
A. That is not a Dubbs operation.
1210 Q. No, it is a once through operation.
A. It is a once through operation. The next time you take some other charging stock, take gas oil, made up of gas oil and some other material, this reflux, and you run it through exactly the same way.
Q. Yes.
A. Right?
Q. Yes.
A. That is not Dubbs either.
Q. No, I understand that.

A. That is not Dubbs.

Q. But I didn't ask you that question.

A. What did you ask?

Q. I asked you whether when I did that I would get these advantages that you were talking about, about solvents and preventing carbonization of tubes, and so on.

A. Not in the same way, no.

Q. Why not?

A. Because that material which is going into the coils is not of the same composition as it would be in a Dubbs operation.

1210 1077 Q. Under those circumstances you think the reflux you get on a once through operation 1211 would not act as a solvent?

A. No, I didn't say that. I said that it was not a Dubbs operation and the action would be somewhat different.

Q. I am not asking you about the Dubbs operation. I am asking you whether you get those advantages.

A. Advantages over what?

The advantages that you have enumerated. I asked you what are the advantages for reflux and you outlined them to me, one, two, three, four, five. Now I want to know if you would have those advantages if you mixed that oil and put it through in the way I have indicated, in a once through operation?

A. Well, let's see. By running that way you should be able to get a low cracking per pass and get a reasonably good ultimate yield. It is rerunning and rerunning and rerunning. It is not a continuous process.

Now, the other advantages in the return of the reflux —well, you certainly would get that advantage that I have outlined. That is, you would be able to get a fairly high yield with a lower cracking per pass, 1212 but the material that you are returning is of somewhat different composition. The fact that it has to be cooled and drawn in the yard would, of course, mean more heat would be required to accomplish the result, and it is not a continuous process.

Q. It is continuous, isn't it? You are feeding 1212 1078 in and taking out all the time.

A. Well, I beg your pardon. Yes, it is a continuous process, not the cycling operation. Well, I

think you would get a good many of those advantages insofar as the operation in the tubes goes. Of course every run would be different. Your first run is based solely upon the charged gas oil. The second run is very similar to the first one, and after you have kept going that way for a long period of time you probably would build up a reflux in that tank which would have pretty good solvent properties, and so on.

Q. Wouldn't you think the first reflux would have the solvent properties?

A. No, that would be somewhat different. It would act somewhat the same way in the action in the tubes B, but it would not be as economical nor as successful,
1213 and it is not the teaching that Dubbs has outlined.

Q. I am not worrying about the teaching of Dubbs at the present time. I am asking you whether you would have those advantages. Would you get this solvent action that you are talking about?

A. I think ultimately, yes, you would get a good deal the same action.

Q. Well, wouldn't you get it immediately?

A. To a certain degree, yes.

Q. Well, to a great degree?

A. Well, to a pretty good degree or a sub-
1213 1079 stantial degree, yes, you would get all of them. The fact that you are putting through the tubes material which has been subjected to a cracking operation and which has gone through the separation of the heavy ends from that material, along with the fresh feed, would have that action which I have described.

Q. And the advantage under those circumstances of immediate recycling is the conservation of heat, it it not?

A. Well, that is one of the big ones, yes.

Q. Well, is there any other?

1214 A. Yes.

Q. What is the other?

A. As soon as you begin to recycle you get a reflux which remains a substantially constant composition. After you recycle for a short time and you get your plant on-stream and it stays on-strean as a constant operation—

Q. Don't you get that as soon as you get your reflux in your tank after you have run through once

and get your mixture of the reflux and the charging stock? You get the same thing, do you not?

A. Every reflux that is produced in one of these runs is somewhat different than the reflux that was produced in the earlier run because there is a different charge going to the tubes.

Q. Isn't it also true that when they operated these plants that they knew nothing about the reflux ratio?

A. When they operated the plants they knew nothing.

Q. They were guessing at it.

1215 1080 A. There is no particular reflux ratio taught in the Dubbs patent. There was no specific statement that the reflux ratio was to be 2 or 3 or 4 to 1.

Going back now to this once through operation, the first run you have nothing going through the tubes but gas oil. The second run you have going through the tubes a mixture of gas oil and some 1216 condensate which has been through the cracking tubes once. It is a different composition charge than you had when you were charging gas oil alone.

Q. May I interrupt you there one minute? Won't that reflux if mixed with the charging stock give you all the benefits, according to these theories that you have enumerated, except the heat?

A. I was trying to explain that that second run does not give you the same composition charged to the tubes, by quite a difference, as you would get from the Dubbs operation in which you are recycling.

Now, at the end of the second run you have got a reflux condensate, a condensate which is of still different composition than it was at the end of the first run, and so on and so on, but after you have run that way for a long time, fifteen runs more or less, ten or fifteen runs. I then believe that the material which 1217 would be going through the tubes might approach the composition of the material that would be sent to the tubes in the Dubbs operation, but in the Dubbs 1217 1081 operation where you are recycling you get that material cycling around and around through the operation and it soon reaches a sort of a steady competition, and then you get it pretty well ironed out and it goes that way continuously for quite a while. And as you have indicated, by putting that material

right back into the coils of course you conserve the heat which is in there, which is a very important saving in addition to that.

Q. Now, it it your contention, Mr. Brown, that when you mix this charging stock of the Dubbs patent with the reflux that has been through the operation once you don't get the advantages that you have enumerated?

A. No, I didn't say that. I said you probably do get those advantages to a substantial or a large degree.

The Court: May I interrupt here? I wanted to ask whether you mean the same thing by charging stock and fresh feed.

1218 Mr. Hall: Yes.

Mr. Thiess: Yes, it is exactly the same thing.

The Court: I thought so, and then once or twice I had thought you were distinguished between the two and I didn't know what the distinction was.

1219 The Dubbs patent specification tells us that the reflux is returned from the fractionator either to the tank L, in this optional arrangement, or the inlet of the B tubes.

The reflux has to be returned to a zone of at least 100 pounds pressure per square inch to get into the B tubes that have frictional resistance.

1219 1082 Therefore in order to get the reflux back into the inlet of the B tubes the reflux must be under a pressure in excess of that of the oil in the B tubes.

1220 Q. Now, the specification of the Dubbs patent doesn't contain a single word, does it, as to how the reflux is to be forced back?

A. Yes.

Q. If it is to be returned directly instead of indirectly by the tank L?

A. Yes. Here it is, page 1, line 87:

"The portion of vapors condensed while passing through vapor lines E, manifold G and aerial condenser G' are automatically drained back through these lines into drainage line F and from there through line F' enter into line J' and back into the heating tubes B."

In other words, he has provided a hydrostatic head which automatically carries that reflux condensate

back into the tubes B, and that is the only thing which is automatic about it.

Q. In other words, you read the hydrostatic head into the word "automatically"?

A. Well, he says it is carried back automatically. That means without any further attention.

Q. Well, my question was correct then, wasn't it?

A. That means the structure of the apparatus is such that the reflux condensate automatically drains
1221 back through the line F, F¹, into the heating tubes B.

Q. Then I am right, am I not, that you read
1221 1083 hydrostatic pressure into the word "automatically"?

A. Well, that is the only thing that is automatic about it. I mean the hydrostatic head as shown in the apparatus is what makes this operation as he described it with the reflux condensate going back automatically. That is the preferred operation.

Q. How much hydrostatic head have you got expanding this model of the Dubbs patent PX 511 into an operation with the 20-foot tubes?

1222 The Witness: I think it is about five feet more or less. It is the vertical distance from the line J¹ up to the junction of the goose neck at the far end.

Mr. Thiess: Q. You can come right over here and look at this, Mr. Brown.

A. Yes, it is vertical distance from this line J¹.
1223 The head could be from the level of the line J¹ up to the level back here or into this line (indicating), which is the horizontal line in the aerial condensing system. It is up to this line back here (indicating), which is the horizontal line connecting the vapor lines E with the drainage line F at the end of the C tubes opposite the condenser G¹ or the lower horizontal line connecting the vapor lines E with the drainage line F. That would be about five feet or perhaps a little bit more.

1225 In the operation of the Dubbs patent there would be no trouble forcing oil with that sort of a
1225 1084 head into the line in which you were pumping oil into the B tubes. The only pressure that that five-foot head has to overcome is the friction loss of the oil going through the B tubes. It does not have to overcome the total pump pressure because it has a pressure on the end which is substantially

the same, so that the T connection of that type with a five-foot head would operate successfully to draw in the desired amount of reflux, operating that plant the way Dubbs has described it and as I have described it.

1226 Q. Do you consider that a pump would be within the skill of the calling to substitute that for the hydrostatic head?

The Witness: One of the modified operations to which you have called my attention, page 2, shows how he can use the pump to force this reflux condensate into the tubes B from the tank L, so that if the material is of such nature that it can be handled by the pump that is available, he has disclosed how it can be done.

Mr. Thiess: Q. Well, would you consider it within 1227 the skill of the calling to substitute a pump for hydrostatic pressure as of that time?

A. That would be ordinary skill?

Q. Yes.

A. Why, I should think so, if you had a pump that would operate under those conditions.

I have stated that I have been actively engaged in the industry since about 1925. I do not mean 1227 1085 to say by that that I was actively engaged in this industry as an operator or anything of that kind with respect to cracking processes for the purpose of producing gasoline. It was about that time that I started to do some work in cracking plants.

Q. What was your first contact with an oil company which was commercially practicing processes to produce gasoline?

A. First connected with such company?

Q. Yes, that you were actually working for.

A. Well, I think perhaps I misconstrued your 1228 previous question. I think perhaps the first one was the Phillips Petroleum Company. I did some work for them about 1925 or 1926. That work was on motor fuel. They were testing cracked motor fuels, straight run motor fuels and natural gasoline blends. I was not working on their cracking operation at that time. I was testing the motor fuels. Soon after that I did some work for the Universal Oil Products Company on some of their cracking units. I think I started that work about 1926 or 1927.

1229 I received no retainer from them. I have been working for them at intervals since then. At to work for other companies that I have referred to, in the Shell Petroleum Company, that was work on vacuum distillation primarily. On the Socony-Vacuum particularly through their White Star division at Detroit. I have worked on motor fuels on some property damaged by a discharge from their trap, and on some operations on a cracking unit. I worked for a couple of days on that. I think that plant went in about 1934 or so. It has all been torn out since then.

1229 1086 I advised the National Refining Company on the purchase of a distillation unit.

1230 I did quite a bit of work for the Natural Gasoline Association of America on utilization of natural gasoline in motor fuels and the properties of motor fuels as related to engine performance. At that time the Natural Gasoline Association of America was interested primarily not in cracking but in the gasoline recovery from the hydrocarbon gases.

Now they are involved in a great many other operations which do involve cracking. My work with them was on motor fuel primarily. That began about 1925 or 1926 and went for about four or five years.

The motor fuel was derived from cracked gasoline, straight run gasoline and natural gasoline blends.

As to the nature of the work that I did for the Universal Oil Products Company, I had quite a bit
1231 to do with the furnace, I know, that went in on the Pennzoil job which was—well, one of the first of the significant changes they made from the type of plant as shown here in this Exhibit 581. I spent quite a bit of time on that, and at various times I have advised them on other things, other plants. I have been working with them on and off ever since about 1927 or so. I had occasion to inspect numerous units and visit a number of plants.

In my direct testimony I stated substantially that a Mid-Continent crude of good grade, approxi-
1231 1087 mately 25 per cent of the crude by simple distillation was gasoline and 5 to 7 per cent was kerosene, thus leaving 70 per cent of the crude available for cracking purposes. I do not mean to say that

the percentages I have given apply to all Mid-Continent crudes. There is quite a deviation in that.

1232 I do not know the percentage of gasoline, gas oil and kerosene contained in the crude as used by defendant.

1233 The stipulation shows that in defendant's operation there was 7800 barrels per day of 38.7 gravity crude oil passed through the heat exchangers in this unit.

I don't know how much of that crude oil was charged to the unit. There is nothing that states that the 3911 barrels which were charged to this unit came wholly from this stream, nor does it state that all of the material not topped out of the 7800 barrels is the 3900 barrels. I am not sure what happened to the 7800 barrels.

1234 Q. Now, using this Mid-Continent crude which you have referred to, which you stated contained 70 per cent gas oil, will you please state how much gas oil could be obtained from this oil if submitted to a coking operation?

The Witness: If we take a crude which has had approximately 30 per cent topped off of it and you wish to run that crude in atmospheric coking stills, the

1235 gas oil equivalent that could be obtained from that would be perhaps 90 per cent more or less, recovered as gas oil, but I don't recall what the loss is on gas and coke.

1235 1088 It is true that at or before the time that the Dubbs application was filed, coking operations were used to produce gas oil for cracking purposes. The gas oil used in a Burton or a Burton-Clark operation was a moderately light gas oil and I don't know for sure, but I believe that perhaps you might get 55 or 60 per cent of the crude available as a satisfactory charge for the Burton operation by some such combined operation as has been outlined. I don't know if it would be any higher.

1361 1089 Q. Dr. Brown, I would like to make sure that I fully understand your position in regard to what would constitute separation in a continuous coil, such as the B tubes of the Dubbs patent. Separation might occur, as you testified on page 1150 of the record, as a result of a very low velocity so that the liquid would flow along the bottom of the tubes and

the vapor would flow along the top of the tubes, is that correct?

A. Yes, if that condition exists there is separation.

Q. And as I also understand and you testified on page 1144 of the record as follows:

"Well there might be some technical discussion, I suppose, between technical men as to exactly at what point the liberation took place or exactly what point you went from a foam into a spray."

By this I understand you mean that when a foam becomes a spray this also constitutes a liberation or separation of vapors from liquids, is that right?

A. Well, that is the borderline or zone in which I say there may be some discussion and that discussion was brought about by your question regarding 'without substantial vaporization.' And I wanted to make myself clear on that, that 'without
1090 substantial vaporization' meant in the Dubbs patent without substantial separation or that the conditions were equivalent or substantially similar to no separation."

1362 Q. Let me ask you, the question I am asking you here is, whether when a foam becomes a spray why then you have liberation or separation of the vapors from the liquids, is that correct?

A. I think so, yes. I think that is where I would draw the line.

Q. Now can you explain, if you will, what the difference is that you see between a foam and a spray as you have used those terms?

1363 A. Foam is a system in which there are the two phases, liquid and vapor, but in which the vapor is present as bubbles within the liquid, the liquid
1363 1091 being the continuous phase; while spray, on the other hand, is just the opposite. The spray is a condition where the vapor is the continuous phase and we have drops of a liquid in the vapor.

Q. Now, let me ask you, how would one determine as regards the condition in a coil containing liquid and vapor whether the mixture is in the form of a foam or spray?

A. If it is in the form of a foam all of the liquid which is present can act as a solvent for the other liquid because the liquid is the continuous phase, and the liquid will be carried through with the same

average velocity as the vapor. If it is present as a spray, on the other hand, then the particles of liquid are not in contact with each other, they are separated by vapor or gas and the liquid particles cannot act as solvents on each other.

Q. How would one determine that? How would one know whether one was working in—

1364 A. You mean on a furnace?

Q. In a foamy condition or a condition of spray?

A. You mean in a cracking furnace, for example?

Q. Yes.

A. There is quite a change in the operating characteristics when you go from a foamy condition into the spray.

Q. How is that determined? How would an operator determine it?

A. When it is in the foamy condition the liquid particles are carried through with the stream the entire foamy mass passing through with substantially the same velocity, going around a turn or bend, or anything of that kind, your foamy condition exists and any liquid that might tend to concentrate on the outer radius of the bend is in solution, main-

1092 tained in solution and then the liquid is carried out through the tubes with the same average velocity. When we come to a condition of spray the liquid is not in continuous phase, we have particles of liquid suspended in the gas or vapor; and as that mixture goes around a bend or other disturbances

1365 these particles of liquid are thrown out from the vapor phase and light on the tubes in which case the tubes, being hot, and there is no liquid coming along to dissolve this heavy particle which is deposited on the tube, that heavy particle may rapidly go to coke or carbonaceous material and coke deposition will occur far more rapidly under those conditions.

Q. How could you determine that? How did you determine that, by calculation?

A. How did I determine that where?

Q. Well, if you were operating, how would you know whether you were operating in a condition of spray or foam?

A. Well, they are of quite different characteristics readily appreciated when you are operating a furnace under those two conditions.

Q. Well, how would you know? That is inside of the coil, how would you determine that, by calculation?

A. How would I know under what condition, Mr. Thiess? You mean how would I know in defendant's operation, or determine, or how would I do what?

Q. When an operator is operating a still, we will say he is operating the still, how does he know whether the condition of the oil in the tube is foam or spray? Is that calculated ahead of time so he would know or how would you determine that?

A. I don't know how someone else might know, I have to have my conditions if I am to work that
1366 1093 out for you. In the case where the quantity of vapor bears a relationship to the liquid such that the volume of the total stream occupied by the vapor is less than a certain value, which we can estimate reasonably well, we know that under the conditions existing in the furnace, that mixture will be in a condition of foam and not as a spray.

Mr. Thiess: Q. What is that critical value?

A. It depends upon the conditions in the material and other things.

1367 Q. Well, take the Dubbs patent and the illustrative runs mentioned in the Dubbs patent, what would the critical value be there, do you know? Have you calculated that?

A. In the Dubbs operation as set forth in the patent this condition inevitably follows.

Q. What would that critical value be: did you calculate that?

A. It would depend on conditions, I could not say exactly, but at 100 pounds pressure and 860 degrees, if the volume occupied by the vapor, that is the volume of the stream occupied by vapors does not exceed 150 times that occupied by the liquid, I feel entirely confident that will be in the foamy condition. The exact line of demarcation I cannot give you very sharply. But I feel entirely confident that if that
1368 ratio of volume occupied by the vapor divided by the volume occupied by the liquid, does not exceed 150 in the tube, that will be a foamy mass.

If it does not exceed that, I feel confident that it will be in the foamy mass. But I do not mean to

say the reverse, if it does exceed that, the foam will break and it will be spray.

1368 1094 I do know where the other limit is where it will break and will be a spray. I cannot give you that definitely, but I know it will be quite a bit larger than that. It may be a thousand or it might be some other value, I don't know.

As to how I arrived at or obtained that figure of 150 and whether I calculated that: Take in the defendant's operation where that relationship is evi-

1369 dently about the same value in the separator. We have at the bottom of the separator a foamy mass, and in the upper portion of the separator we have vapors which have separated from the liquid. And as the vapors are going through this process of separating from the liquid of the foamy mass at the bottom part of the separator, we find that the ratio of the vapor to the liquid in the foam changes from the bottom of the separator as we pass up to the level of approximately try cock 3.

The velocity at which the material is moving affects that. If the velocity up through the vapor separator were appreciably larger that would probably carry this foam to a higher level.

The much higher velocity in the coil tends, of course, to prevent the separation. The higher the velocity the less likely it is the foam would break.

1370 I feel entirely confident that if that ratio does not exceed 150 that we are in the foamy condition in the coil.

That figure which I have given is something that was the result of calculation I made.

Calculations are involved in it, of course. I don't know whether someone could have made those

1370 1095 calculations as of 1919. I imagine somebody could have made them if they had wanted to do so. Data were available; it perhaps could not be

1371 computed quite as accurately as we do now, but that could be computed. But that is not necessary of course in the Dubbs operation, it is not necessary to make any computation at all, because the Dubbs operation as described in the Dubbs patent automatically takes care of that. You just cannot help it. Nature takes care of itself.

You operate the Dubbs apparatus as disclosed in the patent and follow his teachings and you inevitably get that condition. You cannot help yourself. You get that condition when you have vapor generation to the extent of 85 per cent by weight and 95 per cent by volume. I am assuming, of course, you are up to 100 pounds pressure or higher.

1372 I have not always been positive of that. I don't know exactly when I first came to the conclusion that that was absolutely true,—perhaps about 1934, somewhere in there. That was subsequent to the Root case. I had no occasion to study it before that.

It is true that in the Root case I testified ~~that~~ I was not certain whether with 85 per cent vaporization you would obtain this result and that with 90 per cent vaporization I did not know whether you would or not. Since then I have obtained more

1373 information and I have had a better chance to study it. The particular item of information which I have obtained since the Root trial which puts me in the position to obtain the figure now and not at or before the Root trial is the condition that exists in defendant's vapor separator, wherein the foam breaks under the conditions existing in that separator at

1373 1096 a point where the volume occupied by the vapor divided by the volume occupied by the liquid is considerably in excess of 150.

I had a condition of foam breaking in the vapor separator in the Root operation, but I had had no occasion at that time to make that calculation. At that time I had not made it and did not know.

In my statement on direct examination with respect to the defendant's operation, as follows:

"As stated in the stipulated drawing, about 5 per

1374 cent of the stream volume is occupied by the liquid or about 95 per cent of the stream volume is occupied by these bubbles of vapor so that the entire mass passes through the transfer line as a foamy mass." the last phrase is not part of that stipulation. In other words, I did not mean to imply that it was stipulated that the vapor was in the form of bubbles or that there is a foamy mass passing through the transfer line.

The same thing that I have given before is in part

my basis of knowing that there is a foamy mass in the transfer line of defendant's operation.

1375 I had made no calculation at the time of the Root case to determine whether there was a foamy mass in a transfer line when you had 95 per cent vaporization by volume. I had at that time no cause to consider those conditions.

1376 I believe it is impossible to operate a useful process as described in the Dubbs patent without the generation of considerable vapor in the B tubes. And certainly there is no limitation of any operation to the conditions set forth in the illustrative run.

1376 1097 I believe it is impossible to operate according to the principles set forth in the Dubbs patent and not obtain vapor generation in the B tubes.

1377 If a pressure valve was put in the transfer line between the B and C tubes and if you maintained a pressure on the transfer line sufficiently high to keep the oil in liquid form in the tubes, and then released the pressure when you get into the C tubes,

1378 I think you could, under those conditions, operate without vapor generation in your B tubes and obtain the vapor generation and separation wholly in the C tubes.

1380 I think I have stated that in the operations of the illustrative runs of the Dubbs patent, in the defendant's operation, in the operation at Independence, and in the various commercial operations of the Dubbs process, vapor and liquid existed in the furnace coils in the form of a foamy mass. My basis for saying that is not that vapor and liquid exist in defendant's separator in the condition of a foam where the ratio of vapor to the liquid volume is greater than it is in any of the operations enumerated.

The statement that I made regarding the separator in defendant's operation was in answer to your question as to what the limit might be at which the foamy condition would persist; and I stated that I believe that as long as the volume of the stream occupied by the vapor did not exceed 150 times the volume of the stream occupied by the liquid, I felt confident the foamy conditions would exist provided, of course,

1381 that the velocity was sufficient to maintain the turbu-

lent condition and not so low as to allow the liquid to flow along the bottom of the tubes and sepa-
1381 1098 rate from the vapor as does take place in the C tubes of the Dubbs patent.

As to whether I have any basis for the conclusion that foam exists in the furnace coils of these various operations other than defendant's vapor separator conditions, in those various operations vapor generation may vary from low, perhaps 40, 45 or 50 per cent, up to perhaps about 90 per cent as a maximum by weight, approximately those values; and in that region the condition, provided there is sufficient velocity to maintain a turbulent condition, is of a foamy mass. Now we can see conditions of that kind, as I have at various times in glass tubes in the laboratory, things of that kind, but the question to which I referred to the separator was the limitation about which I was asked.

I cannot recall any actual tests or measurements that I have made to determine that such a foam actually exists in a furnace coil or the transfer line when the ratio of vapor to liquid is as you have stated, 150 to 1.

1382 Q. Do you know of any published authorities that support your statement that a foam would exist in the furnace coil or transfer line when such ratios of vapor to liquid volume are present?

A. Oh, I have seen statements; but I do not know whether you would call them published authorities or not.

Q. Well, have you those statements available? Do you know where they are?

A. Well, there was a statement made in some litigation that 99 per cent vapor generation was a foamy condition.

Q. In a litigation?

1382 1099 A. Well, I have seen that statement, I say I don't believe you would call it scientific authority but at least it was a statement that was made.

Q. Do you know of any scientific authorities where this statement is made?

A. I cannot recall any right now.

1383 Q. Then am I right in—could you tell me what litigation that was made in?

A. If I recall, it was in the Champlin case, I am not sure. I was not in the case. I saw it in the opinion or in the record somewhere.

Q. Well, do you depend for your foam theory solely and entirely upon the stipulation that a foam exists in defendant's separator at the points you have mentioned?

A. No.

Q. In other words, it is your understanding, your belief, that that may be true, and you have seen it in this litigation, is that correct?

A. My experience generally indicates that you have a foamy condition when the volume occupied by the vapor is certainly one hundred times that occupied by liquid; and I believe it goes beyond that; but when you ask me for a limit I wish to choose the conditions which were with hydrocarbons such as they existed in the furnace and the same type of hydrocarbons existing in the separator of defendant's operation as existed in the furnace, so I think the best information I have which will set a limit which might apply to the furnace conditions

1384 1100 in a cracking furnace such as defendant's furnace, were those that might be taken from the vapor separator.

Now stating what things in my experience justify this statement, I can remember some years ago puzzling about how much gas there was in beer foam, but that was many years ago, and we made some measurements and we found the volume of gas there varied greatly, if I recall, over one hundred times the volume of liquid, well over a hundred. Those are not precise measurements, they were done when I was a student in college. That foam was in a static condition at the time.

1385 I think the velocity of the vapor and the gas together in defendant's separator is something over one foot per second vertical velocity, about one and one tenth feet per second.

The velocity of vapor in the separator where it is not separated from the foam would be somewhat

1386 more than that but within about one per cent of that

velocity; it would be very slightly greater. As you go down from the point where the foam breaks, of course, we have more and more liquid present and therefore the volume occupied by the vapor is less than approximately the same quantity of foam flowing up through the entire separator so the velocity of the vapor would be somewhat more, but at the third try cock, or thereabouts, I believe the vertical velocity of the vapor to gas in the separator is approximately 1.1 feet per second. Just about that point is where you get this separation, somewhere in that zone, as I told you there is some uncertainty exactly where that separation takes place but it is some-
1386 1101 what above that position. The velocity of the vapor in the separator above the foam is substantially the same.

Mr. Hall: Mr. Thiess, if you wanted that, we have the decision where that is referred to, Gasoline Prod-
1387 ucts Company versus Champlin, right there (indicating). In the Circuit Court of Appeals, finding of facts.

Mr. Thiess: Q. I will call your attention to the decision in the case of Gasoline Products Company versus the Champlin Refining Company, Circuit Court of Appeals of the Tenth Circuit, which counsel for plaintiff has just handed me, and there is the statement which he called to my attention; and I ask you whether that is the statement you have in mind.

A. In order to get this straight perhaps I better go back a few lines.

Q. All right.

A. "When the stream has passed through 60 per cent of the final banks,"—that is the stream of oil flowing through the cracking furnace and the final bank is the final bank of tubes, the last bank of tubes in the furnace,—"the gasoline content is 21 per cent.
1388 When the stream leaves the furnace, 95 per cent by weight is vaporized and the gasoline content is 23 per cent. At the outlet of the roof tubes, nearly 50 per cent of the stream by volume is vapor. As it leaves the first six rows of the final bank nearly 90 per cent by volume is vapor, and when it leaves the furnace 99 per cent by volume is vapor. As the

vapors form, they mix with the liquid and form a fume or foamy mass which travels through the cracking tubes at high velocity."

1388 1102 Q. That is the statement you had reference to?

A. Well, I saw the statement, I think, in the record of the case but it amounts to substantially the same thing.

I don't know what is meant by "fume" particularly, but the foamy mass I think is the same expression meaning the same thing that I have meant when I used that language.

1389 Q. Now, Mr. Brown, will you please point out where in the Dubbs patent in suit there is any reference to the word "velocity" of the hydrocarbons?

A. Well, off hand I do not recall any, Mr. Thiess.

Q. I don't believe there is. Will you also please point out where in the Dubbs patent in suit there is any reference to the word "foam."

A. I do not recall any, either.

Q. And is there any reference in the Dubbs patent to the word "spray"?

A. I think not.

1390 Vapor phase cracking process properly conducted will operate for very long periods of time.

1391 I do not know of any Winkler-Koch operations in which the oil is completely vaporized in the coils, but there might be.

1392 I inspected an operation at the Danciger plant. I am not clear on whether there was complete vaporization in the coils.

1393 Whenever the material is completely vaporized in the sense that it is all converted into the vapor state there is, of course, no liquid present. And when it it is all vaporized, that does not come within the teachings of the Dubbs patent.

1394 1103 The reflux ratio of approximately 2 to 1 which I have given for defendant's operation is given, I think, on a by weight basis.

1395 I believe my testimony in the Root case was limited to a description of the defendant's operation. I have stated that the effluent made in defendant's high temperature coil continues to crack in the vapor separator. The per cent of gasoline made by this crack-

ing in the vapor separator to the total gasoline made in the process is approximately one per cent.

1396 The percentage of the amount of gasoline made from the high pressure furnace stream in the vapor separator to the total gasoline made by cracking in the vapor separator is approximately 17 per cent; 16

1397 or 17 per cent. There are other hydrocarbons produced by cracking of the effluent of the high temperature coils in the defendant's separator. Well, there would be some gas, pressure distillate bottoms, and some material boiling in what we might call the gas oil range. I do not know that I can give you all those figures very closely. I should say approximately the gas oil, that is the material boiling in the gas oil range, made by cracking of the steram from the high pressure high temperature furnace in the evaporator would be roughly the same as the amount of material cracked to gasoline. That is an approximation but I think it is close enough for this purpose.

1398 The circulation of the Dubbs patent as shown in Exhibit 509, consists of reflux condensate which drains back through the tube F, the tubes F^1, into the

1399 1104 cracking coils B, and passes through the cracking tubes B, the transfer line, into the vaporizing tubes C and passes up through the tubes D, and are refluxed in the dephlegmating system composed of the tubes E, G and G^1 and returned back to the tubes F; so that this reflux condensate material just goes around there in a cycle. It is cycled through the B tubes and the C tubes.

If this reflux in tubes F was returned to the C tubes and cycled through the C tubes and went out and came back, I would call that more a shuttling; it is not circulation, it does not go around, it is not cycled, it simply goes back and forth. It goes up in the D tubes, comes down through some tubes that are not shown on this drawing, back again to the C tubes and then up again to the D tubes. Sort of a shuttling action.

1400 I would call that a shuttling of the flux condensate back and forth between the C tubes and the dephlegmating system.

The reflux does not go over the same path when it goes through the B tubes. It comes up through the D tubes in the form of vapor. It does not go back to

the same point from whence it came, the vapor does not go back to the D tubes, or not back to the same point at which the vapor came from, from the C tubes. It goes back to another point and goes around through a cycle. The cycle consists of the B tubes, the C tubes and the dephlegmating system.

1401 If this line F^1 instead of going to the line J^1, would join with this transfer line coming from the B tubes to the C tubes, that would simply shuttle that material into the C tubes and back up again. I don't think
1401 1105 there would be any cycling in the sense that I am using the word cycling. It goes back and forth between the two points, back and forth between the C tubes and the dephlegmating system, while in the cycle it goes around through the B tubes and the C
1402 tubes. I would prefer to call that carrying of the reflux around that cycle and back to the C tubes shutthing, because I think that more correctly defines the action, like a shuttle train that goes back and forth between two points. It does not go through a cycle. I don't think it makes very much difference what word we use so long as we know what we are talking about, but I would prefer to call it a shuttle action as I think that more correctly describes that action.

1403 On page 1098 of the record I stated "In addition to the separation of the generated vapors in the separator, there is further generation of vapors from this stream passing from the high pressure high temperature furnace into the vapor separator, just as there is in the Dubbs patent."

1405 When I speak of this further generation in the separator, I mean additional generation of vapors caused by substantially the same conditions as the
1406 generation which took place in the high pressure furnace coil, except that in the vapor separator there is no increase in temperature as the material goes from the cracking furnace into the vapor separator, while in the cracking furnace there is an increase in temperature as the material goes through the furnace. So whatever generation would take place of the high pressure furnace stream in the vapor separator, could not be due to an increase of temperature, while it might be due and is due to an increase of tem-

perature in the furnace coils; otherwise they
1406 1106 are the same.

The Court: Generation of vapor is due to
1407 heat anyway, more or less?

A. Yes; it depends upon the absorption of heat. Heat has to be supplied in order to generate vapors in these hydrocarbon materials, that is correct. Now, as the material goes from the cracking furnace into the vapor separator, there is a decrease in pressure, and also there is continued cracking. And those two factors will cause the generation of vapors in these streams from the high pressure furnace in the vapor separator. Those same two factors also cause the generation of vapors in the stream in the high pressure high temperature furnace; and it would be impossible to have this additional generation of vapors in the high pressure furnace stream in the evaporator unless that stream had received sufficient heat to cause that generation in the cracking furnace. So that the heat has to be applied, as stated, and the heat was supplied in the cracking furnace. This generation that takes place in the furnace coil and the further generation which takes place in the separator is not
1408 vaporization as I say the word is used in the Dubbs patent. The generation of vapors in the furnace coil and the further generation of vapors in the separator substantially parallels the action which takes place in the furnace coil and the separator in the Root operation. I cannot now see any significant difference.

Q. Then it is your position, is it not, that the generation of vapors in the furnace coil and the further
1409 generation of vapors in the separator in the Root operation do not constitute vaporization in the sense of the Dubbs patent?

1409 1107 A. That is right.

Q. That is why, in describing defendant's operation in the case at bar, you used the words "further generation of vapors" with respect to what occurs in the separator rather than the words "further vaporization", is it not?

A. Yes; I am trying to avoid any confusion, because I am trying to use the words in the same way they are used in the Dubbs patent.

Q. Now, I would like to read to you from the Root record, page 571, your testimony as follows: "At

the valve A",—that is the valve in the transfer line, is it not, this valve right here (indicating)?

A. I don't recall now; probably it is.

Q. Well, as we read this, you will understand. I have got it here and you can follow it.

A. Thank you.

Q. That is the valve A. "At the valve A, the stream of oil and vapors is throttled, and it passes through the valve and expands against a pressure of about 30 pounds, which is the pressure in the evap-
1410 orator, so that as the oil passes through valve A into the bottom of the evaporator, an additional vaporazition takes place due to the fact that the pressure is now less than the vapor pressure in the liquid." That is your testimony, isn't it?

A. That is what it says.

Q. Now, in your Root testimony which I have just read, the "additional vaporization" referred to is the same thing which in this case you called, on page 1098 of the record, "further generation of vapors," is it not?

1410 1108 A. That is right.

Q. Isn't it true, Dr. Brown, that additional vaporization in the separator necessarily means that there was vaporization preceding that additional vaporization?

A. At that time the word "vaporization" was used by me to mean "vapor generation", without a doubt.

Q. Now, will you refer to the Dubbs patent and please read from the patent all the statements which you can find which support your understanding and contention that Dubbs used the word "vaporization" to mean exclusively separation of vapors?

A. The first reference is on page 1, line 52, at the
1411 bottom of the column, where it says, "B are the cracking tubes. C are the vaporization tubes"; therefore that action which takes place in the C tubes is vaporization, because he refers to the C tubes as the vaporization tubes.

Then we find that action clearly defined on page 1 in the second column, beginning about line 78:

"Said oil is then passed into the tubes C which are only partially filled with the oil and as the oil passes through these tubes, there is a liberation of vapors from same",

which described the action which takes place in the C tubes.

Another action also takes place in the C tubes, which is stated at the bottom of the second column on page 1, beginning line 108:

"The per cent. of vapors generated from the oil as it passes through the tubes C will depend on the amount of heat acquired by said oil while passing through the 4" coils."

1411 1109 Those three statements clearly define that C is the vaporizing tube and that by vaporizing or vaporization he means the action which has been described beginning line 78. Also in the C tubes there is the generation of vapors which has been so referred

1412 to by that language as "vapors generated" on line 108.

We find the same idea repeated on the second page. Line 31 he again refers to the C tubes as "the vaporizing tubes C."

And then in the example where he is treating these oils of 32 to 36 Baume, beginning line 40,

"The heated oil then passes to the 10 inch coils C which are maintained about half full of oil and wherein vaporization takes place."

Again describing the same action, that the tubes are partly filled with oil and the vaporization takes place in these tubes which are partly filled with oil.

"The residue is constantly drawn off through the pipe K to a suitable storage."

That is, the residue from the vaporization, from the separation.

You did not wish me to refer to the claims, did you?

Q. Certainly, I want to get everything in the patent.

1413 A. In the first claim beginning at the upper right-hand corner of page 2, a process is described of converting relatively heavy into lighter hydrocarbons, consisting in passing a stream of oil through a zone where the oil is heated to a cracking temperature but without substantial vaporization. That language "without substantial vaporization" cannot exclude vapor generation because in the example given there is clearly vapor generation in the B tubes; and furthermore in the original application as filed, in

1413 1110 the only claims which are at all complete, the statement reads, in claim 1 of the original application:

"A process of converting heavy into lighter hydrocarbons, consisting in passing the oil through a heat-
1414 ing coil in a cracking zone,"—that is the B tubes—"passing the oil and generated vapors into a vapor chamber"—which are the C tubes,

and so on.

The same statement appears in the second claim: "A process of converting heavy into lighter hydrocarbons, consisting in passing the oil through a heating coil in a cracking zone, passing the oil and the generated vapors into a vapor chamber."

So that clearly as filed he recognized that there was generation of vapors in the B tubes.

1416 The illustrative run to which I have referred was not in the application as filed, but the two claims in the original application which I have just read were in the application as filed, and the third claim is incomplete as originally filed. So that the only claims in the patent as filed clearly stated that he was passing oil and generated vapors from the B tubes into the tube C; so that there can be no doubt that vapor generation was included in the B tubes.

Then in the example which is in the patent and, to the best of my recollection, was in the application prior to or at least at the same time that these later claims were made, it is inevitable that vapor generation takes place in the B tubes. Therefore, because in the original application he clearly recognized that vapor generation took place in the B tubes, and because of this example which was in the patent
1416 1111 when these later claims were introduced, vapor generation was inevitable, and the phrase "without substantial vaporization" in these claims cannot exclude vapor generation. So that you read in this first claim in the patent as issued, where he heats
1417 the oil in the cracking zone without substantial vaporization, passing thence to and through a zone where vaporization takes place, removing the vapors and subjecting them to reflux condensation, returning the reflux condensate for further cracking, removing the residue after said vaporization. Now we do

not have a residue after vaporization unless that vaporization includes a separation, because in order to get residue there must be a separation of some kind. Because the phrase "without substantial vaporization" does not and cannot exclude vapor generation and removing the residue after said vaporization, it seems clear to me the term "vaporization" must include a step in which there is a separation which forms the residue.

And we find that same statement again in the second claim, "removing the residue after said vaporization."

And in the 5th claim it is clearly stated that while preventing substantial vaporization in the tube B, then in tube C affording a vaporization space above the stream.

1418 Now, if there is a vaporization space above the stream, that is clearly a space in which the vapors separate from the liquid. You could not have a vaporization space above the stream, and have the generation of vapors in that space above the stream.

1418 1112 And it seems to me that both in the patent as issued and as filed, and in the claims, it is perfectly clear that the word "vaporization" must include the separating step, and the phrase "without substantial vaporization" does not exclude vapor generation.

Q. Now, this claim that you have referred to in the file wrapper, claim 1, it says,

"Passing the oil and generated vapors into a vapor chamber."

There is no statement in the patent or in the claims which quantitatively define how much that vapor should be, is there?

A. There is no quantitative figure in the patent as filed as to how much vapor is taken off in the tubes C, is that what you mean?

Q. Yes.

A. I think that statement is right.

1419 Q. I think we did not get it right. It says, "Passing the oil and generated vapors into a vapor chamber." Now, in original claim 1 there is no statement which quantitatively defines the amount of generated vapors in the B tubes that are passed into the vapor chamber.

A. No. There is no limitation as to the amount of generated vapors in the specification as filed.

Q. Now, you have read quite a number of excerpts from the patent, which you tied up and said they mean to you that vaporization must mean exclusively separation of vapors. Is there any
1419 1113 statement in the patent in words in which Dubbs says that vaporization means exclusively separation of vapors?

A. You mean does he use that exact phrase?

Q. Or does he say in words so that one, without going through the operating deductions that you have, could read and understand that he means by "vaporization" an exclusive separation of vapors?

A. Why, I think so. He says throughout the claims, "without substantial vaporization in the B tubes."

1420 Q. And that means to you that he means an exclusive separation of vapors, that would be a statement to a man skilled in the art to mean that?

A. I would like to finish it.

Q. Oh, I beg pardon.

A. He says in the claims "without substantial vaporization in the B tubes;" therefore what occurs in the B tubes is not vaporization. And he says C are the vaporizing tubes, and he tells you what takes place in the vaporizing tubes, at least twice.

Q. And in the vaporizing tubes he also tells you, does he not, at the bottom of page 1, line 108.

"The per cent. of vapors generated from the oil"—.

A. That is right.

1420 1114 Q. —"as it passes through the tubes C will depend on the amount of heat acquired by said oil while passing through the 4" coils"?

A. That is right, and that is why I told you the other day that it might be interpreted that vaporization in the Dubbs patent would mean the combined operation of generation and separation, but that it could not mean generation alone. In other words, it might be interpreted to include all of the actions
1421 which take place in the C tubes in so far as vapor generation and vapor separation take place. But in my opinion the word "vaporization" is used in the Dubbs patent to mean the separation or the liberation of vapors.

Q. Have you now stated all of the references in the Dubbs patent which you understand define the word "vaporization" to mean exclusively separation of vapors?

A. I think I have stated practically all of them; there may be some others in there, but those are the ones upon which I have been relying for that interpretation. I think they are clear.

The Dubbs patent does not state in words in the patent that the conditions in the B tubes are such that the continuous phase is liquid and the vapors would be the discontinuous phase.

1422 The teaching of low cracking per pass is very clearly taught in the return of the reflux condensate. Dubbs does not need to say things of that kind in specifically so many words; anyone would get that.

1422 1115 He talks about the return of this reflux, oh, beginning page 1, line 23,

"while the reflux condensate is returned to the cracking zone for further treatment."

And again line 32,

"the reflux condensate is continuously removed from the refluxing condensing apparatus and returned to the inlet side of the system,"

which clearly states he is producing insufficiently cracked material as reflux condensate, and returning that to the inlet of the B tubes for further cracking or for further treatment; which means it clearly

1423 states to anyone at all familiar with the cracking operation that he is making a low cracking per pass and then re-cracking the insufficiently cracked material. He can get a high yield with a low cracking per pass.

Q. Well, but you, if I understood you, said that Dubbs taught the utliization of a low cracking per pass?

A. That is right.

Q. Isn't it true you can also get a high cracking per pass with the return of reflux?

A. You can get a higher cracking per pass, yes. High and low are relative terms.

Q. What do you mean by low when you refer to Dubbs?

1424 A. I mean that he teaches the operation of the return of this reflux condensate which is insuf-
1424 1116 ficiently cracked material so that he can get what we call a low cracking per pass or get a high yield, a much lower cracking per pass for the given yield than would be possible if he had not returned the reflux condensate, but there are no limitations as to what the cracking per pass here would be, nor are there any limitations as to the yield. But he states at the bottom of page 2, the first column, that

"The gravity of the distillate discharge from the water cooled condenser is about 52 to 56 Baume and in quantity is approximately some what more than half of the gas oil subjected to treatment,"

which indicates for that time a high yield of pressure distillate and a high yield of gasoline, a higher yield than could be obtained in a satisfactory operation on a once-through basis, and he is getting that yield with operating conditions which are very satisfactory, made possible by the low cracking per pass or other operating conditions; and the return of the reflux clearly teaches that he is not cracking to make
1425 the total yield per pass he is getting a low cracking per pass and getting a high yield and returning the insufficiently cracked material for further treatment.

You ask if it isn't true that cracking per pass in an operation where practically all of the cracking is done in the coils depends on the cleanliness of the charging stock. I do not think that has any relationship at all. The cracking per pass and the cracking of the material going through the tubes determines the severity of the conditions and the length of time that you might keep that furnace operating; but I don't see any direct relationship between the cracking per pass and the cleanliness of the stock.

1425 1117 Length of time is an element.

1426 Q. Well, let us go to the defendant's operation. You have stated, have you not, that in the defendant's operation Exhibit 598 with the flap down shows the Dubbs process?

A. That is right.

Q. Now, with the flap down there is no charge going to the process and according to the Dubbs

teachings the reduced crude would be introduced into the coil, would it not?

A. The defendant's operation with the flap down represents a Dubbs operation with the gas oil feed and the gas oil being fed into the dephlegmator.

Q. Well, let us take the feed that is fed to the defendant's operation, a reduced crude, and let us feed that into the defendant's operation as Dubbs teaches.

A. This is an entirely new operation, is it not, neither defendant's nor anything else right now, is that it?

Q. It is the operation which I understand you have shown on this plat. You haven't shown any place where this charge is fed, and the feed to the defendant's operation is reduced crude, is it not?

1427 A. I state again, Mr. Thiess, the operation indicated with the flap down on PX 598 corresponds to a Dubbs operation with gas oil feed, the gas oil being fed into the bubble tower or dephlegmator. In this operation gas oil has been topped out of this reduced crude.

Q. Let us keep this flap down.

A. The gas oil has been topped out of the reduced crude in the vapor separator, and that gas oil from the reduced crude passes over as a vapor through the heat exchanges and is condensed in the bubble tower, and that gas oil which is topped out of 1118 the reduced crude constitutes the fresh feed to the high pressure, high temperature cracking coil, so that the operation as shown with the flap down is exactly equivalent to a Dubbs operation with gas oil fed into the dephlegmator, that gas oil being the fresh feed and in combination with the reflux condensate formed in the dephlegmator or bubble tower constitutes the combined feed which is the total material supplied to the high temperature cracking furnace.

There is, of course, some heavy naphtha which is also fed to the high temperature cracking furnace in exactly the same manner as is disclosed in the Dubbs patent.

1428 I am asking you to take the reduced crude which is the material that defendant desires to crack and

feed that into the combined feed line to the high temperature coil.

A. This is a slightly different operation than shown in defendant's plant.

Q. In other words, you are using a reduced crude as the charging stock and feeding it directly to the coil.

Mr. Hall: Your Honor, it seems to me you might be led into confusion. Of course this testimony is for your benefit. That is why we are taking it.

Mr. Thiess: Right.

Mr. Hall: Consequently we should have this clear. When the flap is down, I think, as the witness has said you have there, you are using just what we have called the Dubbs process. It would be equivalent, I think your Honor understands, to feeding as a fresh feed a gas oil stock. Now, Mr. Thiess, as I now understand it, desires to depart from that operation to this extent: In this question he is going to take this device with the flap down but instead of using as his fresh charge gas oil he is going
1119 to use topped crude. Now, if that is clear that is all I want.

1429 I think you could operate successfully, charging a reduced crude to defendant's operation. As to how long you could operate depends upon how you operate again, how much cracking per pass and things of that kind. You could also operate unsuccessfully if you wanted to.

1430 Using the cracking per pass that defendant uses, perhaps you would want a lower cracking per pass, perhaps you would want a higher temperature, perhaps you would want a lower temperature. You have got a different material in the tubes. Perhaps they operated with different pressures and different conditions when they charged topped crude to the coils than when they charged gas oil.

The character of the charging stock determines, along with other factors, the duration of time that the furnace can remain on-stream without cleaning it.

Q. How long do you believe that this operation shown on PX 598 could run, charging reduced crude to the coil and keeping other operating conditions the same?

1431 A. I don't think anybody in his senses would want to operate that way.

1431 1120 Q. In other words, it wouldn't operate?

A. I didn't say that.

Q. Well, what did you mean by "anybody in his senses would not operate"?

A. The conditions when operating a cracking furnace on a combined feed composed of gas oil and
1432 reflux condensate would not be the most satisfactory conditions for operating that same furnace when charging topped crude and reflux condensate.

Q. Is there anything in the Dubbs patent that teaches that?

A. Teaches what. That the conditions would be different?

Q. That the conditions should be different.

A. Nothing specific in there, no.

Q. You have heard the testimony of the witnesses in these Dubbs operations where they fed fuel oil, and so on, through the coil, have you not?

A. Those operations are on a simple plant in which there are less independent variables subject to control by the operator. For example, the pressure in the separating chamber is substantially the same as the pressure at the outlet of the furnace, and under those conditions you have a more automatic plant. It tends to compensate for itself. In this plant you have a valve between the furnace and the separator which is subject to independent control by the operator, which enables him to control the operating con-
1432 1121 ditions to a greater degree than is the case in the simple plants that do not have that valve, and
1433 this plant is less fool proof than the plants that do not have that valve.

If you fed gas oil into this operation shown on Exhibit 598 and didn't cool the separator, but did reduce the pressure, of course the temperature in the separator would be a good deal higher than it is here and that means you would have a different character of reflux condensate and I imagine you would have considerably more carbon formation in the vapor separator because the temperature would be higher and you would have present in the vapor separator a heavier residue than you now have, and that carbon would accumulate to a much greater extent than it

1434 does now. Under those conditions temperature of that vapor separator would be pretty close to the temperature of the transfer line.

That temperature of the transfer line is 940 under these conditions, but of course if you tried to operate that way you would get a different character reflux condensate and that might change the conditions at the outlet of the furnace, so that it is hard to state exactly.

But suppose that the temperature in the vapor sep-
1435 arator would be roughly 100 degrees higher than it is now, you would get a much higher rate of cracking in that vapor separator.

1435 1122 Q. How much higher rate?

A. I don't know how much material would be in that separator under those conditions.

Q. Well, at a temperature such as you have just mentioned in defendant's vapor separator would the reflux be clean?

A. "Clean," Mr. Thiess, is a purely relative term and that term "clean circulation", if that is what you have in mind—I don't know whether it is or not—is that what you wish me to talk about?

Q. Well, that is all right. Give me a definition of what you mean by clean circulation.

A. Clean circulation—

Mr. Hall: We have been all over this once or twice.

Mr. Thiess: No, we haven't.

The Witness: "Clean circulation", as applied to the Dubbs process in the Dubbs patent, means that the material which is circulated through the B tubes,
1436 the C tubes and the dephlegmating system, that is the reflux condensate that we were just discussing a few moments ago, goes through a cleaning step each time it goes through the cycle, that cleaning step consisting of the vaporization which takes place in the vapor chamber or the C tubes, in which only the volatile hydrocarbons are included in the reflux condensate, and all the hydrocarbons which are non-volatile under those conditions are removed from that cycle each time it goes around the cycle, so that the circulation is cleaned up, each time it goes around the cycle, of the non-volatile, high molecular weight unsat-

1436 1123 urated material, and that is called clean circulation because the circulation has been cleaned up each time it goes around.

Q. By the witdrawal of the residue?

A. By the separation of the residue which is the high molecular weight non-volatile material, that material being kept out of the cycle, out of the reflux condensate withdrawn.

Q. Being withdrawn?

A. Yes, kept out of the reflux condensate.

Q. Is there any teaching in the Dubbs patent to keep this out of the reflux except by withdrawal of
1437 of the residue from the reaction chamber, the C tubes?

A. The statement is made on page 1, beginning line 23, "The reflux condensate is returned to the cracking zone for further treatment substantially free from carbon."

Q. What do you mean by that, "substantially free from carbon"? That would mean some carbon could be carried along, would it not?

A. Well, carbon or carbonaceous material, of course, is volatile under certain conditions, depending upon the character of the stock, and so on.

Q. Does he make any distinction between the character of the stock, and so on, when he says—

A. No, no.

Q. So that according to this statement some of the carbon can be carried on with the reflux, can it not?

1437 1124 A. Well, "substantially free from carbon" means that the reflux condensate, as he says here, "returned to the cracking zone for further treatment substantially free from carbon," means to my mind substantially free of these heavy polymers which are of a carbonaceous nature.

1438 Q. Well, that would permit some, wouldn't it?

A. Well, as I tell you, there are, of course, all degrees of unsaturation and all degrees of molecular weight, and the material which is vaporized in a vapor separator will contain unsaturated material in the vapor and it will contain high molecular weight material in the vapor. Some of that material is of a carbonaceous nature, of course, but after it gets to a certain degree of polymerization so that it has such a high molecular weight and such a low volatility that

it is not volatile in the vapor separator it then stays behind in the residue.

Q. Does Dubbs teach that in his patent?

A. That is what he says.

Q. Where he says "substantially free from carbon"?

A. Substantially free from carbon.

Q. You get all of that out of those four words, do you?

A. Yes. Those materials which are loaded with carbon, the very carbonaceous materials, the high molecular weight non-volatile materials, go out in the residue, and the only material of a carbonaceous
1439 nature which can be in this reflux is the material which can be vaporized. We can vaporize material
1439 1125 which but that material is nowhere near as bad as the heavier molecular weight less volatile material which is left behind in the residue.

Q. But Dubbs makes no such distinction in his patent?

A. I think he does right here in the words "substantially free from carbon."

Q. All in the words "substantially free from carbon"? Are there any others?

A. Before that he says, "The carbon containing residue is continuously removed from the cracking zone."

Q. That is the withdrawal of the residue from the reaction chamber we talked about before, is it not?

A. All right. "While the reflux condensate is returned," and then again a little later, page 1, line 32, "The reflux condensate is continuously removed from the refluxing condensing apparatus and returned to the inlet side of the system," meaning that he is returning only reflux condensate, and that is returned.

I have kind of lost the original question you asked me.

1440 Q. The question I asked you was whether you could point out where in the Dubbs patent he states that the reflux should be free from carbonaceous material.

A. Independent of removing the residue?

Q. Independent from just saying withdrawing the residue from the reaction chamber.

A. In other words, independent of withdrawing the residue, the statement that the reflux condensate is substantially free from carbon material?

1440 1126 Q. That is right.

A. I think I have read that.

Q. That is the only reference you know of, is that right?

A. That says it very clearly. I think that is adequate.

Q. Will you answer the question? Is that the only one you know of?

A. That is the only one I can recall right now, where he says the reflux condensate is to be substantially free from carbon without linking it with the removal of the residue.

1441 Q. Now, am I correct in interpreting your testimony that this so-called solvent theory which you have presented is explainable merely in the light of present day knowledge which was not available at the time the Dubbs application was filed? You referred to that, page 353 of the record.

A. No. Knowledge of that kind was well known to physical chemists. The advantages of the solvent were two-fold as I recall. One, it dissolved these heavy polymers and retarded their rapid formation of the carbonaceous material; and, secondly, because it dissolved these high molecular weight materials it carried them out with the stream at approximately the same average velocity as the stream going through the furnace. Now, you have reference to each one of those separately?

It was well known prior to Dubbs that a second order chemical reaction was retarded by dilution with the solvent, by chemists, and I am not sure at the 1442 time of Dubbs how many people appreciated that the formation of the carbon was a second order reaction.

The Court: What is a second order reaction?

The Witness: A reaction in which it is neces-

1442 1127 sary for two molecules to come together, sort of a polymerization or similar type of reaction.

Mr. Hall: What is the first order?

The Witness: A first order reaction would be a reaction in which a single molecule will decompose or break down. Those who appreciated at that time that the formation of carbon was a second order re-

action depending upon the different molecules coming together would appreciate the effect of the solvent on retarding that action, and I believe that everyone would appreciate that the presence of a solvent to dissolve these high polymers would keep those high polymers in solution and carry them out of the furnace with the same average velocity as the rest of the stream. Whether or not Dubbs had all that in his mind, of course, is very questionable but information of that kind was available.

1444 In simple distillations there is some decomposition of unstable compounds such as the sulphur compounds and other molecules, and undoubtedly some slight decomposition of some of the hydrocarbon molecules, but the operation is essentially that of separating the materials which are present.

In the same way if we start to screen some gravel we may in the course of screening break up some of those particles, but the prime operation is simply a separation.

Whatever cracking would take place under ordinary distillation would be purely incidental and would have no appreciable effect on the results of the products obtained.

1445 A coking operation represents a good deal of cracking and there might be some material boiling in
1445 1128 the gasoline range produced, but of course the material would be withdrawn by vaporization from that still long before it had gotten down to the boiling range of gasoline because the still is operated at a high temperature and as soon as the material has been cracked down so that it will vaporize under that temperature condition it will vaporize
1129 out of the still, so there will be very little if any
1446 material boiling in the gasoline range produced by that operation. The percentage would be very small.

Q. You have produced a number of samples of oil which you say came from the Wilcox-Dubbs plant at Bristow, Oklahoma?

A. That is right.

Q. Will you please describe the operation conducted at this plant from which these samples were taken?

A. That plant had a furnace very similar to the

one shown on Exhibit 581. As I recall, the reaction chamber or the vapor chamber instead of being 10 by 10 was about 10 by 40.

I think the oil in there leaves the same as shown on this Exhibit 581. I think it was substantially the same as that except that it was 40 feet high. The tempera-
1447 ture of the oil as it left the furnace was about 935 to 940 degrees and the pressure at the outlet of the furnace was about 200 pounds. As I recall the pressure at the inlet was about 340 pounds. I think they were charging about 1500 barrels of topped crude per day.

The residue from the vapor separating chamber was withdrawn at a very low level or practically no level in the vaporizer, and this residue was then carried off to another separator which was operated at 10 or 12 pounds pressure, where further vapors were removed.

Q. How was the reduced crude charged to the unit?

A. As I recall it went into the dephlegmator. I have some of the notes I took when I was at that plant. I would like to check with those. Yes, the topped
1447 1130 crude was charged into the dephlegmator.

Q. Is this the reason that you were unable to obtain a sample of the reflux?

A. That is right.

Q. Do you know how this sample that you have produced for the reflux, as representative, was obtained in the laboratories of the Universal Oil Products Company?

1448 A. I did not take that sample and I am not familiar with how it was produced or taken.

Q. Have you seen reflux taken from any of these units?

A. Yes.

Q. That is mixed with the feed?

A. Well, I had a sample of the reflux mixed with the feed from one unit.

Q. I mean a reflux without the feed. Have you seen that?

A. Yes, I have seen that in some direct feed operation.

Q. Where did you see that?

A. I can't recall that but I know I have seen it.

Q. How do you know that the sample that you produced here that you obtained from the Universal

laboratory is representative of the reflux obtained in these various operations?

A. All I know about that sample is that it was taken from some operations at the Riverside laboratory and handed to me as a reflux produced out there at Riverside. Now, it has generally the appearance, and so on, of similar material produced in the plants. That is all I know about it.

1449 1131 Q. Now, referring to the residuum sample which you have produced from the Wilcox-Dubbs plant, where was that obtained?

A. From the bottom of this vapor separator, which was this 10 by 40 foot chamber.

Q. That is, it was taken before it was passed over to the low pressure chamber?

A. Yes.

Q. You say the operation was conducted with a low level in the reaction chamber?

A. An extremely low level. I mean there was just a litle liquid in the bottom, to make a seal, probably.

Q. Do you know why that was done?

A. That was the way they were operating.

Q. Would they under those circumstances have obtained any cracking in the reaction chamber?

A. Yes.

Q. How much?

A. I don't know.

Q. Wouldn't the greater part of the cracking occur in the coil?

A. I wouldn't be surprised. I don't know, Mr. Thiess. I haven't figured it at all.

1450 In the Dubbs operation the oil, as it leaves the B tubes goes through the transfer line, comes up into the C tubes from the bottom. If there was any vapor in this transfer line when it was fed with the liquid into this C tube I think the vapors would separate from the liquid very rapidly, within a very few feet or so of that point, anyway, of where that pipe entered the C tube.

1450 1132 The purpose, under those circumstances, of the remainder of these four C tubes, is, as stated in the patent, additional vapors were generated in the C tubes by a continuation of the cracking reaction dependent upon the heat which the oil has received

in going through the B tubes, so that it is substantially correct that the greater part of these C tubes are provided so that you would get cracking in the
1451 C tubes. I think the separation alone would take place in a sufficiently satisfactory manner in one or two tubes and it would not be necessary to put in the four of them.

Q. Just a moment ago you told me, I understood, that the separation would occur very soon in the first C tube, did you not?

A. Well, there would be a foamy mass coming into that end of the first C tube, and it takes time for these foams to break and separate cleanly. As you noticed the vapor is not withdrawn from that C tube until it gets down to the far end. I believe by the time it has gotten down to the far end of that first C tube, or some time prior to that, the separation will be substantially complete and that there will be no significant entrainment of liquid in the vapor line marked D. The points beyond there, as you have pointed out, would then not serve any additional function insofar as the separation goes except that the additional tubes D to carry the vapor off might relieve the vapor load on the single D tube and might help a little in that way, so that the greater part of this C tube functions primarily as a reaction chamber.

1452 1133 Q. Now, am I correct in my understanding that it is your contention that the Dubbs patent teaches a velocity for the material in the B tubes below which velocity one cannot go without encountering trouble in the carbon formation in said tubes?

A. Well, I would put it perhaps a little differently than that, that the Dubbs patent clearly teaches a velocity which is sufficient to prevent the separation.

Q. As I understand it you get this teaching of this velocity from the statements in the Dubbs patent, that the oil should be heated in the B tubes without substantial vaporization, is that correct?

A. Not necessarily, no. He provides a sufficient head in the drainage system to force the oil through the B tubes—the B tubes are short and there is only a small number of them—with a sufficient velocity to maintain the turbulent state in the B tubes. And it

was well known at that time that for efficient heating of the oil the oil should move through these small
1453 tubes with as much velocity as possible.

Now, to anyone familiar with the operations at that time the description of the apparatus and the known skill in heating oil, that is the application of ordinary skill in heating oil in tubes, would indicate that the oil would go through those tubes, with as much velocity as the plant would provide, and the plant is so laid out as to provide sufficient velocity.

Q. But do you find anything in the patent? Can you read—now, I want words from the patent, any statements made by the patentee which refer to velocity.

1453 1134 A. I think I told you before I could not recall offhand the use of the word "velocity."

Q. Is there anything in the patent, in the teachings and words, which cautions against permitting the velocity to fall below a certain level, a certain value?

A. Well, not directly but there is indirectly, and of course that was well known to those in the art at that time anyway.

Q. That you needed a high speed?

1454 A. For efficient heating we wished to put the oil through the tubes at as high a speed as we could obtain.

Q. That was well known by everybody, was it?

A. Yes, for heating oil particularly at that time.

Q. And that it would be rather silly to put the oil through the tubes at a low rate of speed?

A. Well, otherwise I see no point in using B tubes and C tubes. It would simply be a case of just putting a bunch of big tubes in there and pushing the oil through them.

Q. I am asking you whether the art knew it?

A. They did at that time. That was well appreciated.

1456 Q. In order to maintain the same temperature on the oil in the C tubes as prevailed at the outlet of the B tubes it would be necessary to put heat into the oil in the C tubes, would it not?

1458 A. If there is cracking taking place in the chamber and if the temperature is to be kept constant of the

material as it passes through this chamber, it will be necessary to put some heat into the material passing through that chamber equivalent to the heat of cracking which takes place therein.

1458 1135 Q. Is it your contention that it is or is not contrary to the teachings of the Dubbs patent to add enough heat to the oil in the C tubes in order to maintain the temperature therein the same as the temperature at the outlet of the B tubes?

A. Dubbs does not teach that.

Q. Is it contrary to his teachings?

1459 A. I think it is. He says on page 1, line 99:

"A light fire may be maintained under the tubes C as shown in the drawings or said tubes may be heavily insulated with cel-o-cel insulating material or any other well known insulating material to prevent loss of heat by radiation and thereby dispense with the fire under the tubes C."

Which is a very specific statement that he is trying to prevent heat loss. In other words, do not add or subtract any heat from the oil in these tubes.

Q. Due to cracking and vaporization?

A. No. Do not add or subtract any heat from the oil in these tubes by heat radiation through the tubes. By radiation, to prevent loss of heat by radiation. That is what he is trying to accomplish.

Q. The other loss he would have would be loss due to cracking and vaporization, would it not?

A. That would not be a loss in heat.

Q. That would be a reduction in temperature?

A. It would be a drop in temperature.

Q. Suppose an operator was operating one of these Dubbs stills and he had a fire under the C tubes, which is the method shown in the patent. How would he be able to determine that he was just sup-

1460 1136 plying enough heat to overcome the heat loss due to radiation?

A. By measuring the temperature of the gases surrounding the tubes and keeping them at the same temperature as the oil in the tubes.

Q. Would that be the way the operator would do it? How could he do it? How would he know that?

A. How would he know what the temperature is?

Q. How would he know what the temperature of the oil in the tubes would be?

A. Put a thermo-couple in there.

Q. The thermo-couple would register the loss of temperature due not only to radiation but cracking?

A. There is nothing about the loss of temperature, Mr. Thiess, in the patent. It is the loss of heat. If the temperature of the gases outside of the C tubes is the same as the temperature of the oil inside the C tubes there would be no heat transfer from the gases to the oil or from the oil to the gases and then there would be no loss of heat. He is not trying to
1461 keep the oil at the same temperature. He is trying to prevent the loss of heat by radiation. He can do it in either of two ways, by having the C tubes surrounded by hot gases at substantially the same temperature as the oil in the C tubes, or by putting heavy insulation on the C tubes, which is a well known method of lagging these pieces of—

Q. I am interested in the first operation. What measurements would he have to take in order to just put in enough heat?

A. He would put in no heat, Mr. Thiess.

1461 1137 Q. Put in no heat?

A. Put in no heat. He would maintain the same temperature of the gases outside of the tubes as he has of the oil inside the tubes.

Q. In order to do that what readings would he have to take?

A. He could do it in a number of different ways. He might put a thermo-couple with one junction in the oil and another junction out in the gases, and as long as the instrument read zero he would know the two temperatures were the same. He might put a
1462 thermo-couple in the oil and another one in the gases and if the instruments read the same he would know the temperature was the same. He might do it in all kinds of ways.

Q. What harm would he do if he added a little more heat?

A. I don't know. Do you mean if he put in what, 10 B. T. U.'s or something like that?

Q. If he added more heat than just conserving the heat lost by radiation?

A. You mean just an insignificant amount of heat, an inconsequential amount? That wouldn't make any difference.

Q. Suppose he put in a substantial amount?

A. That is specifically what he is told not to do in the patent. He is told to prevent heat loss by surrounding the tubes with hot gases or by insulation.

Q. In an operation of the Dubbs patent where, as you have said, the greater part of the C tubes are used primarily for cracking, would you say that it would be outside of the teachings of the Dubbs patent to bring those tubes up to a cracking tempera-

1462 1138 ture to get some cracking?

A. Well, they are at a cracking temperature.

1463 We don't have to bring them up. They are.

Q. All right, we will go into that later on with the model. Now, would the temperature of the oil in the C tubes be the same from end to end?

A. Probably not. If there is cracking taking place, as there is, that will absorb some heat and that heat will have to be supplied by what we call the sensible heat of the oil. In other words, there would be a decrease in temperature due to this heat of cracking, and the material leaving the far end of the C tubes through the line K would probably be at a lower temperature than the material entering the C tubes at the point where the transfer comes from the B tubes.

Q. Now, I would like to ask you a question with respect to this matter of your interpretation of the phrase "without substantial vaporization." Do you consider that phrase to mean, in view of your reference to the Champlin case, the same as the phrase "substantially in liquid phase"?

A. Well, that all depends upon how it is used,

1464 Mr. Thiess. I can hold forth on the meaning of those words for quite a while, if you want me to. I don't know that it would be of any help.

If the person means by "liquid phase" a condition where the mixture has substantially the properties of a liquid, whether it is a foamy liquid or a liquid void of gas bubbles, then the two would be synonymous. If the person means a liquid phase, a distinctly solid liquid phase as distinct from any

1464 1139 vapor, then the two might be different.

Q. As of 1919 what would you say was the meaning that was given to that phrase in the art?

A. Which phrase?

Q. "Substantially liquid phase".

A. Well, "substantially liquid phase" might mean that the material has the same properties as the liquid phase, so that it might be regarded as substan-
1465 tially liquid. That is a perfectly satisfactory meaning for that phrase. Or it might mean that it was substantially liquid, say more than 50 per cent liquid, or 30 per cent liquid, or whatever might be necessary to make it substantially liquid. It might mean either one or the other of those two.

Q. Well, as of 1919 and 1920 would you say that the art, in interpreting the phrase "substantially liquid phase" would have referred to the definition that you gave as substantially in liquid form, or the other one that you gave?

A. Well, it might be either one.

Q. You believe that would be true in 1919?

A. It might be either one, yes.

Q. So that if in a patent, as Egloff, page 1, line 94 or 93, I would say; 92, the patentee says that the oil is delivered from the coil 5 in substantially liquid phase, what would you say this patentee meant?

1466 A. Well, I think either interpretation could be given to the language in that line. It might mean that it is subject to a pressure of, say, 135 pounds in the heating coil 5 and delivered in substan-
1466 1140 tially liquid phase through the insulated transfer line 9 to the expansion chamber 12. I think that language might be interpreted either way. It might be interpreted that the material as it passes through the insulated transfer line 9 is in the main liquid with some vapor bubbles in it, or it may be interpreted that it has the properties of a liquid phase so that it might be regarded as equivalent to a liquid phase.

1468 Q. Could you give me the cracking per pass of the defendant's operation?

A. You asked me before recess to estimate the cracking per pass in the high temperature high pressure furnace of the defendant's operation. According to the stipulation, there are 6,940 barrels of mate-
1469 rial charged to the high temperature high pressure furnace per day. According to the stipulation, there are 1,755 barrels of gasoline produced per day by

cracking and reforming in this furnace. Therefore the cracking per pass to gasoline in that furnace, including the reforming, would be 1755 divided by 6940, which is 25.2 per cent. If we make allowance for the material boiling in the gasoline range in the heavy naphtha charged and subtract that from the gasoline produced by cracking and reforming, we get 1,536 barrels of gasoline produced by cracking in the furnace per day, with a total charge to that furnace of 6,940 barrels per day, or a cracking per pass of 22 per cent.

I do not know how much carbon is produced in defendant's operation.

1470 1141 Describing the Gyro process that I have referred to in my testimony, those Gyro operations have changed quite a bit from year to year. The operation which I had in mind at the time I was referring to it consisted in taking the material that was primarily vapor, putting that through some tubes where it was heated and dried, that is the material which was not completely converted into vapor would remain behind in those tubes and go to coke, and these tubes were preliminary to the cracking tubes; and then the vapors after the mist had been extracted from them in these preliminary drying tubes passed on through the cracking tubes where they were heated to a higher temperature and cracked, and then the vapors went on into the rest of the system for condensation and further treatment.

Q. Do you have any published description of this
1471 Gyro process where the word "vaporization" is used to indicate exclusively the separation of liquid from vapors?

A. I do not recall any. I know it has been described quite frequently but I am not sure whether that language has been used there or not.

Q. Well, where did you get the impression that it was so used in the description?

A. I heard those tubes called vaporizing tubes and drying tubes, I think, in the old plant which was down at Cabin Creek, West Virginia, somewhere in that locality, one of the old Gyro units.

1473 1142 I imagine that the Dubbs process as disclosed in his "629" patent is one which could be operated to produce kerosene. I have never seen it done

so. I don't see why it could not, though. When the Dubbs process makes gasoline primarily, they make kerosene at the same time. It will make material boiling in the kerosene range. I thought you had in mind a process operated to make primarily a material in the kerosene range.

1474 Q. In referring to the illustrative run of 52.54 gravity pressure distillate, you mentioned that something like 50 per cent of this pressure distillate would be gasoline. Let us assume that kerosene was the primary product desired; what per cent of this pressure distillate could be made into kerosene?

1475 A. I might say, if it would answer your question, it would be about the same percentage that could be made out of the P. D. in defendant's operation. Now I will tell you how much that would be approximately. Oh, roughly 65, possibly 70 per cent of it might be converted into material having a boiling range of kerosene assuming, of course, you are making no gasoline out of it as we now know it. I am not making any allowance for any treating loss particularly but it would be about that percentage.

I have testified that at 750 degrees Fahrenheit and 100 pounds pressure there would be at the outlet of the B tubes at least 20 to 25 per cent by weight of the oil in vapor form, and at 860 degrees F., 100 pound pressure, there would be above 90 per cent by weight
1476 or a little more in the vapor form. I was giving those figures as the approximate range that might be expected.

1476 1143 Q. Now let me ask you, how did you arrive at those percentages; was it the result of an estimate or calculation or from the operation of the process?

A. Well, primarily the calculation is based on operations as set forth in the patent. The presssure which was used in each one of these calculations would be 100 pounds. The fresh feed would be about 20 to 25 barrels per day of gas oil. It would be probably
1477 a little less than that at the 750 degree operation, maybe 15 to 20 barrels per day. The pressure distil-
1479 late would be about 60 to 65 per cent of the charge. The reflux ratio that I used was about 3 to 1, and the combined feed ratio about 4 to 1; that is, about four times as much reflux going back to the tubes as is

fresh feed. The per cent of gasoline in the pressure distillate would be upwards of 50 per cent, say between 50 and 60 per cent, something of that nature. The temperature at the B tubes inlet and the outlet in both of them, would be, approximately, I think at the B tube inlet it might vary from a low of about 525 or 540 up to about 600 or a little bit more, depending upon the temperature of the charge and other things.

1478 For the C tube temperatures at the inlet and outlet, the inlet would be the temperature stated in the example, say, 750 or the 860. And the outlet, well, I don't know that I have that figure. It would be somewhat little less than that, a few degrees less, say, I haven't figured that out, I don't know. Maybe five to twenty or five to twenty-five, something like that. Somewhere in that range.

1478 1144 The pressure distillate yield in gravity was
1479 about 60 to 65 per cent of the charge and I believe that gravity would be somewhere around 52 to 56 as stated in the example. I think that is what I took. The residuum withdrawn, percentage in gravity would be about 15 or 16 degrees A. P. I. And the yield would be about, oh, 25 to 30 per cent, something
1480 like that, maybe a little more, it would depend of course upon the yield of the pressure distillate. Say about 30 to 35 per cent for the residue. The per cent of the charge which left the system in the form of uncondensed gas I should think would be about 8 to 9 per cent by weight. The gravity of the charging stock was I think about 34 to 35 degrees. The temperature of the reflux before mixing with the fresh feed would be a little higher than the combined feed, perhaps about 625 to 700 or 725. The temperature of the combined feed entering the furnace would be something between 500 and 600 degrees, something in that nature.

1481 The per cent of conversion per pass would be about 9 per cent of conversion to gasoline. How much of that was made in the B tubes and what part in the C depends somewhat upon conditions. It might vary from—well, that would vary of course depending upon the operating conditions from about, perhaps, 30 per cent of it down to about, oh, let's say, 10 per cent, from 10 to 30 per cent of the gasoline produced in

the cracking then would be produced in the B tubes in the example and in the plant as shown in the patent drawing.

1482 1145 The end point of the gasoline would be between 400 and 423 degrees Fahrenheit.

1483 Mr. Thiess: Now what I would like to do is to extend this model PX 511 into the 100 feet B tubes and 80 feet C tubes.

A. 100 feet B and 80 feet C?

Q. That is correct.

A. Oh, you mean as represented in the patent drawing?

Q. In the patent drawing.

A. That is right.

In the illustrative run, you charge a certain charging stock through J-1 into the B tubes, and with 750 at the outlet of the tube and the 20 to 25 per cent
1484 vapor generation in the B tubes the oil would come in at 500 or 525 and probably get to a little over 600 at the end of the first tube, and reach 700 or so at the end of the second tube. Those are approximate figures.

The linear velocity of the oil at about 700 or 720—oh, I don't know, would be perhaps half a foot a second or three-quarters of a foot a second, something like that where you reached that temperature. At 700 there would be some vapor generation.

1484 1146 Q. Well, at that point you would have sepa-
1485 ration of liquids and vapor, wouldn't you?

A. No, I don't think so.

Q. You would not have separation of vapors and liquid at a speed of three-quarters of a foot per second?

A. Not under those conditions, no.

Q. You would not?

A. I don't think so.

Q. Well, then, as the oil progressed through the coil at the three-quarters of a foot per second, how much time would the oil be in the remainder of the 60 feet of the B tubes?

A. Well, it increases in velocity as more vapors generate at the higher temperature, but if we take an average velocity through the last three tubes, is it?

Q. Yes.

A. Of about three-quarters of a foot per second?

Q. Wouldn't the velocity be higher as you go along?

A. It may average a little more than that, it might average nine-tenths or possibly one foot per second.

1486 If it averaged one foot per second and 60 feet, it would be in there for one minute.

Q. Would you say it would be one foot per second or would you say it would be less than one foot per second?

A. I don't know. It would be more than one foot per second at the outlet, but as I estimate it would be less than one foot per second at the end of the second tube.

1486 1147 Q. In between those two places would there be any separation of liquid and vapor?

A. I think not.

Q. If you were flowing oil through that coil at three-quarters of a foot per second, and you had any substantial vapor generation, wouldn't you have separation?

A. You mean by substantial generation 95 per cent., something like that, or do you mean 15 per cent?

Q. The amount of vaporization that you would get at the 750 operation that you calculated?

A. No, I think not.

1487 Q. In other words, is it your position that if you are flowing through that coil at, let us say, three-quarters of a foot per second, and you had over 20 per cent vapor generation, you would not get separation?

A. Well, you wouldn't have over 20 per cent vapor generation at that point, I don't think.

Q. Well, let's take 10 per cent vapor generation.

A. I think not at 10 per cent.

Q. The speed of three-quarters of a foot per second is a pretty slow speed, isn't it?

A. As modern furnaces go, yes.

Q. And if you had water flowing in a trough at a speed of three-quarters of a foot per second, and you put some powdered cork on that water, would you consider that the cork would float—

1487 1148 A. Oh, I think the cork might float on the water, yes. Of course, we are not talking about water and cork in these tubes.

Q. Well, you are talking about oil and vapors, are you not?

A. That is right.

1488 Q. And the thing that makes the cork float is the same as the thing that makes the vapors separate from the liquid, it is gravity, is it not?

A. Well, the buoyant action of the water on the cork tends to make the cork float; and the buoyant action of the liquid on the bubbles of vapor tend to cause the bubbles of vapor to rise through the liquid. But we have an entirely different situation with water and cork, which is a liquid and a solid, than we have in the case of oil and bubbles of vapor under the high temperature and high pressure of the cracking furnace. There is no comparison between those two.

Q. And you don't think at three-quarters of a foot per second the vapors would float on the top of that oil?

A. Under those conditions that exist in that furnace, I think not, with the amount of generation we have been discussing.

Q. Now, let's go back to the length of time that—do you remember the length of time you gave me that this oil would be in the B tubes after it got to an active cracking temperature?

1488 1149 A. If we take an average velocity of one foot per second through the last three tubes which are sixty feet in length, it would be in there for about one minute.

Q. How much cracking would you get at the 750 in the one minute?

A. At 750, that might be as high as, oh, 8 to 10 per cent per hour, perhaps.

Q. How much would you get per minute?

A. That would mean about 1/60 of that, about a quarter of a per cent or so a minute.

Q. How much cracking would that be?

A. A quarter of a per cent a minute?

Q. Very low, wouldn't it?

A. Yes, that is rather low from modern standards.

Q. Substantially no cracking?

1490 A. Well, it is a quarter of a per cent a minute.

Q. And a quarter of a per cent of the amount of material that you said would flow through this tube would give you how much cracking?

A. Oh, that is roughly something under a gallon per hour of gasoline. I think about 6/10 of a gallon per hour.

Q. Then you have what per cent per pass?

A. You mean in the tubes there?

Q. In the B tubes.

A. 6/10 of a gallon per hour; that is about, oh, half a per cent approximately per pass.

1491 As we pass from the B tubes to the C tubes, I think you have got over 20 per cent vaporization.

1491 1150 A. That vapor would be liberated from the liquid primarily as it passes through the first C tube.

1492 Q. In the first part of the first C tube?

A. Yes, it would be liberated in that first C tube.

Q. And how much cracking under those circumstances would you get in the C tubes with that material passing from the B tubes into the C tubes at the 750 temperature?

A. Well, the cracking continues through those three B tubes where we get about a half per cent per pass, through the transfer line where we would get perhaps a little more, maybe a third of that again, then into the C tubes, and the vapors do not remain in the C tubes very long, but the liquids remain in the C tubes for a much longer time.

Q. How long would that liquid remain in the C tubes?

A. It depends on the level maintained, and so on.

Q. Take the level that you assumed in your calculation.

A. I think I stated there was 9 per cent cracking per pass, approximately, did I not?

Q. Well,—

A. If there is 9 per cent cracking per pass, and
1493 that half of one per cent occurred in the last three B tubes, perhaps another 15/100 per cent in the transfer line, and maybe a little bit more in the first B tubes, then we subtract from the 9 per cent per pass about 7/10 of a per cent, and we end up with about 8.3 per cent cracking in the C tubes.

1493 1151 Q. Now, what would be the temperature of the oil in the C tubes with that amount of cracking and without putting any heat in the C tubes,

giving effect to the heat consumed in vaporization and cracking?

A. If the material remained in the C tubes for an hour or a little more, that would be adequate to account for that amount of cracking.

Q. Would the material remain in the C tubes for that length of time?

A. Well, let's see, I thought that would, evidently. Those 10-inch tubes, yes, it would remain in there more than an hour, being about half full.

Q. And how much liquid would be in there, about two barrels?

A. Well, the capacity is about 330 gallons. And we
1494 are putting combined feed in there of about 125 gallons an hour, or about 125 to 130 gallons per hour.

Q. And with that feed it is your understanding that it would remain in there about an hour?

A. It might remain in there for about an hour with the level somewhere near the half full position.

Q. And under those circumstances you say you would get this 8.3 per cent cracking?

A. About that.

Q. About that; what do you mean by about that?

1494 1152. A. Well, that is about the way I would estimate that particular plant as described in the patent drawing and in the example and the apparatus. I think I am taking a little more through-put for the 750° temperature than I previously gave you. I think I told you at the 750 transfer the feed would be about 15 or 20 barrels a day, which would be about 60 barrels combined feed per day, which would be less than this amount of oil. So what I am using here is the quantity of oil that I think would be the proper through-put when operating at 860, and you have been applying the 750 temperature to it, so I feel sure that
1495 my previous statement is correct, that is, that the amount going through per hour would not be 125 gallons per hour at the 750, but would be nearer, would be much nearer 100 gallons per hour, and the capacity of those C tubes being 330 gallons after we make all allowance for expansion and so on, it is clear that the oil will remain in the C tubes for quite a bit longer time than one hour when it is run about half full.

Q. If you got this 8.3 per cent cracking in the C tubes, what would be the temperature of the oil in the C tubes if it entered at 750?

A. It would continue about 750 to 740 in there.

Q. In other words, you believe it would remain at that temperature without supplying any heat, even though you have that amount of vaporization?

1495 1153 A. No, there would be some cooling as I have said.

Q. To what extent do you think the oil would be cooled?

A. Theoretically it figures about 7°.

Q. You would have just a 7 degree drop there?

A. Theoretically.

Q. Now you qualify, theoretically; what do you mean?

1496 A. Well, making a rough calculation as I have, allowing for the heat of the cracking there, 8% cracking, would roughly drop that about 7 or 8 degrees.

Q. Did you allow for the latent heat of the vaporization also?

A. I thought I had included that, but let me see, that is at 100 pounds, the latent heat is extremely small up there. I thought I had it adequately allowed for. For example, the latent heat at 700 degrees of the pure hydrocarbons is from zero to about 30 B. T. U. per pound maximum, and I was allowing 60 B. T. U. for the whole business, and cracking and the vaporization of what was cracked out.

Q. In other words, in the figure that you have given me of a drop of about 7 or 8 degrees you have allowed for both vaporization and cracking?

A. Well, I tried to make some allowance, it might be somewhat inadequate. Well, there is another factor there that should be taken into consideration, the heat of the solution, which might be quite a little bit more, perhaps if we would say from 10 to 15 degrees, something of that nature, that would be pretty close to it.

Q. And that would reduce your rate of cracking in there?

1497 1154 A. Yes.

Q. To what extent?

A. Well, a drop of 10 degrees would reduce it to about three-quarters of the rate, or so.

Q. And would give you what ultimately?

A. That would make it, it would have to be in there four-thirds as long a time.

Q. It would have to be in there an hour?

A. About an hour and fifteen minutes or an hour and twenty minutes, instead of an hour. As I have indicated that quantity of oil will remain in there for over an hour.

Q. And you say it will remain in there for that length of time based upon the rate of feed that you have assumed?

A. For that 750 degrees operation, yes. Of course, if I am a little bit high on my through-put, why, the plant would line itself out perhaps at 12 barrels a day instead of 15 barrels per day.

A velocity of three quarters of a foot per second
1498 is a little over a half mile per hour.

Q. Well now, Mr. Brown, I just want to sum this up by asking you whether it is your considered opinion that under the conditions given in the illustrative run,
1499 namely, a 32 to 36 gravity gas oil, mixed with reflux under a pressure of 100 pounds and at a temperature of 750 and having the percentage of generated vapors you have given, that a velocity as low as three-quarters of a foot per second would be sufficient to insure no separation of vapors from liquid in the 4-inch pipe?

1499 1155 A. No, not no separation, but I believe that mixture would pass through in a condition equivalent to no separation. In other words, there would be no substantial separation. I say we may disagree among engineers as to exactly where separation takes place; but I believe that will be a turbulent mass; whether or not it is absolutely uniform throughout or not, I don't know. I believe it will be what we would class as a foamy mass with perhaps some additional liquid in addition to the foam.

Q. Do you believe there would be any separation?

1500 A. With a small amount of vapor generation and at low velocities, that is approaching these low velocities, I can readily imagine that there will be what might be called slugs of liquid and slugs of foam, if you want to call it that way. In other words, wherever the vapor is present, it will be within the foamy mass, but there may be solid forms of liquid, it won't be

entirely foamy. Now, that might be mentioned—you may classify that as separation. I do not.

I think you would not get a separation where the liquid would be flowing below and the vapors along
1501 the top free from this foam at that rate of speed. At half a foot per second, certainly you are getting pretty close to it, and I don't know exactly where that will come in, but somewhere at those velocities, and you give it time at the low velocities, and do not put it through too many elbows and turns, and things of that kind, you may get separation at those velocities.

1501 1156 It is usually true that the reflux in the Dubbs patent would have an end point of about 850 or 900, that is, under the vacuum distillation, the end point would be 900° F. plus. It is not my position that the process necessarily produces a reflux of this character. Some modifications might produce others; it depends on the temperature, the pressure and the composition of the material in the separator where the reflux separates from the residue.

Q. Would an operation which produces a reflux of
1502 800° F. end point come within the teachings of the Dubbs patent?

A. Well, that really has nothing to do with it; it would depend upon the other conditions.

Q. As I understood you, you always got a reflux of 850 to 900?

A. No, I think I was asked what was the end point usually found in the reflux from these Dubbs operations. As I recall, I said it usually run from 850° F. upwards. Then I was asked if I meant a true boiling point distillate, and I said, no, not a true boiling point distillate, it might be a little higher because the end point of a true boiling point distillate is always higher than it is in the vacuum Engler distillate.

Q. Getting back to the operation would you say that the operation that produced a reflux of 850° F. would come within the teachings of the Dubbs patent?

A. It might and it might not, depending on the other conditions. That has nothing to do with it.

1502 1157 Q. Well, how about 700?

A. Well, it all depends on what kind of a

residue we are making, the temperature and pressure we are maintaining in the vapor separator.

1503 Q. Then under the circumstances isn't it true that the end point of the reflux produced is clearly within the control of the operator?

A. Yes. So are his yields and the amount of the residue and so on.

1504 Referring to the Egloff patent, the patent teaches that the heating coils 5 and 6 form a continuous length of several hundred feet of two to eight-inch pipe, which would be anywhere from, perhaps, four or five hundred up to eight or nine hundred. I would not build eight or nine hundred feet of eight-inch 1505 pipe. I would build it of perhaps four-inch pipe or something of that kind. I don't think I would build it of eight-inch pipe at all. I don't think I would build it of either two or eight-inch pipe. I would take a size intermediate, probably about four-inch.

The expansion chamber is 68 inches in diameter and 40 to 60 feet long. I don't think there is any definite statement that it is insulated, but the insulation of those chambers was very common at that time and I think that equipment would certainly be insulated by anyone building that equipment at that time.

1505 1158 Q. Do you consider the Egloff patent an improvement on the Dubbs process, the 629 patent?

1506 A. It is an improvement if you care to regard it as such in this manner that the charge, instead of going directly to the cracking coils goes through this cleaning step which was involved in the Dubbs cycle before it gets into the cracking coils, so that not only is the reflux but also the charge subjected to a cleaning action which is the vapor liquid separation which occurs in the expansion chamber before it enters the cracking coils or the tubes 6.

Q. If one skilled in the art were to operate the process according to the teachings of the Egloff patent where would the cracking and vaporization in the process take place?

A. The cracking would take place primarily in coil 6 and the expansion chamber, and the vaporization, in the same sense that Dubbs has used it, would take place in the expansion chamber.

Q. What is the purpose of the maintenance of this large body of oil in the expansion chamber?

A. Well, cracking takes place in the expansion chamber, cracking of both the charge which enters the expansion chamber from the coil 5 and also cracking of the material which is discharged from coil 6. Furthermore the vaporization or the vapor liquid sep-
1507 aration which takes place in the expansion chamber serves to clean up all of the material which enters the cracking coil 6.

Q. Does Egloff use "vaporization" in the same sense as Dubbs does?

1507 1159 A. Well, I don't recall finding the word "vaporization" right now. Maybe it is in here somewhere.

Q. Well, you might refer to claim 5.

A. Oh, in the claims?

"A process of oil conversion, consisting in maintaining a body of heated hydrocarbons in an enlarged zone where substantial vaporization occurs."

That might be used in the same way that Dubbs has used it and it might be used in another way. That is to indicate the generation and the separation.

Q. Now will you go to the second use of the word "vaporization" in that claim beginning about line 95?

A. I think that is used in the same way as it is in the beginning. In other words, I think he is using the term "vaporization" to mean the completed op-
1508 eration of the formation of the vapors and the separation of those vapors from the liquid.

1509 Q. In that second clause he says, "and simultaneously heating an independent stream of charging oil for delivery to said enlarged zone to a temperature sufficient to cause a substantial vaporization thereof in said zone." The temperature would not affect the separation, would it?

A. Temperature has a rather small effect on the separation of generated vapors but it has an effect.

Q. Would you say that it was used there for that purpose or not, for its effect on the separation or for its effect on the generation.

A. I think it is the effect on the combined action. I think Egloff is using the term "vaporization"
1509 1160 in claim 5 to mean the usual use of the word when we apply it to evaporation where was gen-

erate the vapors and the vapors separate from the
1510 liquid; and that is what he is referring to, in my opinion, when he says "vaporization."

Q. And that the temperature would effect generation as well as separation?

A. Yes.

Q. If you heated the charging stock in the coil 5 to 770 degrees rather than 700, would that result in an excessive carbonization in the coil 5?

A. Probably not. It depends on the conditions, but I should say probably not.

Q. Under those circumstances what is the advantage of heating this oil separately to the 700 degrees?

1511 A. Well, this is, of course, simply an example which he has put in here as one type of operation, and certainly if he heats the oil, the topped crude oil, to 700 degrees there is much less difficulty of heating that oil to 700 degrees than there might be to some higher temperature. The object of the patent is to treat the fresh oil, which is presumably a topped crude or heavy oil, to different conditions of temperature and pressure than is the reflux condensate which is sent through coil 6, and this is simply an example of one way in which he thought it might be operated.

Q. It is the only teaching in the patent, is it not, of that method of conducting the process?

A. Well, this is simply an example, one way in which it might be conducted. There is no lim-
1511 1161 itation of 770 on the coil 6, nor 700 degrees on coil 5.

Q. But in the example Egloff teaches that his oil is heated to a temperature of 700 degrees in this coil 5 and that it is delivered in substantially liquid phase through the insulated transfer line 9 to the expansion chamber 12, that is correct, isn't it?

1512 A. That is right.

Q. So the oil would leave the oil in substantially liquid form at 700 and enter the expansion chamber, would it not?

A. That is the language he has used, yes.

1514 Q. Now, the oil flowing through the coil 5 leaves in liquid phase and enters the expansion chamber?

A. Now are you talking about this on-stream period of are you talking about—

1515 Taking the operation given in the example and assuming that it has been brought on-stream and that this stream of substantially liquid oil is delivered to the expansion chamber, and we will assume that you have got reflux at 770, which is also delivlivered to the expansion chamber, the oil might enter in the expansion chamber at about 745, possibly 750.

I get that figure by blending the two streams, the one at 770 coming from coil 6 and the one at 700 coming from coil 5. Then as it flows through the expansion chamber cracking takes place.

The cracking takes place in the expansion chamber as a result of the temperature and the time.

1516 The temperature might drop in the expansion chamber from about 740 to perhaps 720.

1516 1162 Q. How much cracking would you get in the expansion chamber with that drop in temperature?

A. Well, the average temperature in there would then be about—oh, let's see—about 730, and at 730 it would crack perhaps four or five per cent. About four per cent per hour, say. I mean crack there to gasoline, about four per cent per hour, or that nature.

Q. As as a result of the four per cent cracking per hour how much vapor would you get in the dephlegmator? I am thinking about, at that rate of cracking how much reflux would you get in the dephlegmator to feed through your coil 6?

A. Well, it again depends on the operating conditions but I should imagine the amount of material going through coil 6 would be about twice what it would be going through coil 5.

Q. You would get that with four per cent of cracking in the expansion chamber?

1517 A. I think so.

Q. Now, Egloff teaches, does he not, that the oil leaving the coil 6 should be in liquid phase, substantially liquid phase?

A. Well, that language is used in this particular example and we discussed that earlier today. He says the material coming out of coil 5, page 1, line 93, delivered in substantially liquid phase through the insulated transfer line 9 to the expansion chamber 12,

and also in line 100, talking about the material delivered from coil 6, he says it is delivered in substantially liquid phase to the vapor chamber. As I believe we discussed that earlier today, that may be interpreted either that the properties of the material
1517 1163 are similar to that of a liquid or that the major part of the stream might be liquid phase, and it is the statement which applies to that particular example.

1518 Q. I want to know how much cracking you would get in coil 6, assuming that the oil leaves the coil in substantially liquid phase, with a temperature of 770 at the exist of the coil and a pressure of 175 pounds.

1520 A. There would be about three and one half per cent of the material passing through coil 6 that would have undergone cracking to gas and gasoline.

Q. Well, how much would you have gasoline?

A. Let's see. Oh, let us call it about three per cent approximately.

Q. Then the effluent from this coil 6 joins with the effluent from coil 5 and goes to the expansion chamber?

A. That is right.

Q. How much cracking would you get in the expansion chamber?

A. Well, the rest of it—

Q. How much would that be?

A. Oh, approximately 10 to 14 per cent of it.

Q. So that the cracking reaction in this Egloff patent under those conditions of liquid phase operation is the expansion chamber, is it not?

1521 A. Well, I don't think that all of those statements have anything to do with the result. It is simply that in this particular apparatus, as shown in the patent drawing and operated in the way he has de-
1521 1164 scribed, would result in this relative amount of cracking in the coil and in the chamber.

Q. That the majority of the cracking occurs in the expansion chamber, that is correct, is it not?

A. Under those particular conditions, yes.

Q. Now, you have stated that Egloff teaches a process in which a stream of charging stock is mixed with a stream of hotter reflux in an expansion chamber, the purpose of which is to make clean charging stock for the hotter stream of the oil out of the oil

flowing in the cooler stream. Will you please read from the patent where Egloff teaches this operation, in words?

1522 A. I think what I said, or at least what I intended to say, was that Egloff intended to treat the topped crude or his charging oil to different conditions of temperature and pressure than he did intend to treat the reflux condensate, which was sent through the high temperature cracking oil, and then you asked me if the Egloff patent involved an improvement over 1535 the Dubbs process and I said yes, because the Dubbs process subjected the cycled material or reflux condensate to a cleaning step each time it went around the cycle. And in addition to that Egloff also subjected and his charge material to that same cleaning step. Now, I think that is the way I made the statement earlier.

Q. Is it your position that the Egloff patent teaches that the charging stock is mixed with the hotter effluent from the coil 6 in the expansion chamber 1524 for the purpose of making clean charging stock in the expansion chamber, which clean charging stock is to be cracked in the coil 6?

A. Whether or not that is the expressed purpose, and I do not believe that purpose is definitely expressed in the patent, the result of the operation disclosed by Egloff is that the charging 1165 oil is subjected to the same cleaning step as is the reflux condensate.

Q. But you do not find any statement in words in the Egloff patent that teaches that type of operation, do you?

1524 1166 A. Well, that type of operation is the type of operation which is disclosed by Egloff. The whole patent discloses that.

Q. But in the Egloff disclosure, as we have considered it, with the qualification that both the streams in coils 5 and 6 are delivered to the transfer line in substantially liquid phase, you agree, do you not, that the greater part of the cracking occurs in the expansion chamber?

A. In the particular apparatus described in the patent and the particular example set forth on page 1, beginning line 87, the majority of the cracking occurs in the expansion chamber.

1525 Q. Now, if it was Egloff's intention to make in the expansion chamber a charging stock to be cracked in the coil 6, can you state any reason why Egloff should teach that the oil in coil 5 should be kept in substantially liquid phase?

A. I do not regard that as a teaching of the patent but simply a statement of fact or a statement of his observation concerning the particular example given.

Q. Well, would that be beneficial if you were endeavoring to make charging stock for the coil 6?

A. No, it would have nothing to do with it. It doesn't make any difference insofar as preparing charging stock for coil 6 is concerned.

Q. Well, if you are preparing charging stock for coil 6 the purpose is to vaporize as much of the oil out of the oil that is flowing through coil 5, is it not?

A. That occurs in the expansion chamber.

1525 1167 Q. As a result of cracking?

A. And heating and decrease in pressure.

1526 Q. Wouldn't it be advantageous now to have oil vaporized in the coil 5 if you were merely endeavor-
1527 ing to make charging stock in the expansion chamber for your coil 6?

A. No. I can see that it makes no difference whatsoever.

Q. Why do you say that?

A. Because the vaporization takes place in the expansion chamber, not in the coil 5.

Q. Well, the vaporization in the expansion chamber takes place as a result of cracking only, does it not?

A. Oh, no, it takes place as a result of the temperature, the pressure and the cracking which has taken place in that chamber.

Q. How much vapor generation would you get in the expansion chamber, disregarding cracking, in this Egloff operation, of the oil?

A. With what temperature and pressure on the expansion chamber?

1528 Q. The ones given in the patent.

A. There would be 135 pounds on the expansion chamber?

Q. Right.

A. And a temperature of about 740 or 745? Let's see now. There would be approximately 35 per cent of the total material supplied to the expansion chamber if there were no cracking in the expansion chamber and the operation were conducted at the same temperature and pressure outlet of coils 5 and 6 and the composition of the material going through coil 6
1528 1168 is the same as the composition was when we got cracking in the expansion chamber. Now, if we don't get any cracking in the expansion chamber the composition of the material going through coil 6 would be different, and that in turn will affect the composition of the material in the transfer line, and that, of course, will affect the vapor generation and the quantity of vapor liberated from the expansion chamber. But if we had an operation, which I think is rather impossible, in which the composition of the material leaving coil 6 would be the same as it is
1529 when the cracking occurs in the expansion chamber, then there would be about 33 to 35 per cent of the total material going through the transfer line vaporized out in the expansion chamber.

Q. When you say "total material" do you mean the effluent of coil 5?

A. Effluent from coils 5 and 6.

Q. How much from coil 5? That was what I had in mind.

A. Well, under the same conditions, if they could be obtained, there would be about 10 to 15 per cent of the material from the coil 5 that would pass off as vapor from the expansion chamber.

Q. The patent says, does it not, that oil is delivered in substantially liquid phase to the expansion chamber?

A. That is what it says in this particular example.
1530 Q. Yes. Well, under those circumstances there would be no vaporization, would there, of the oil from coil 5 because of the meeting with the oil from coil 6?

A. Yes, there would.
1530 1169 Q. Wouldn't that occur in the transfer line if there was any?

A. All right, that would occur in the transfer line and would persist in the expansion chamber and the separation would occur in the expansion chamber and you would have about 10 to 15 per cent of the

material charged to coil 5 passing out through the line 19 as vapor.

Q. Well, now, if you raised the oil to the 145 degrees that you have mentioned—

A. 745.

Q. —or 745, in the transfer line, wouldn't the components of that oil vaporize immediately?

A. There would be some generation of vapors in that transfer line due to the increased temperature brought about by mixing the oil from coil 5 with the hot oil from coil 6.

Q. You wouldn't have any further vaporization or vapor generation, would you, in the expansion chamber except as a result of cracking?

1531 A. If the expansion chamber is maintained at that same pressure.

Q. That is what this patent teaches, does it not?

A. That is what this patent states in this particular example, yes.

1533 Q. The patent says that the effluents from coils 5 and 6 are delivered to the expansion chamber in substantially liquid phase. That is correct, is it?

A. That is what it says regarding this example.

1533 1170 Q. All right. Now, since there is no increase in temperature in the expansion chamber any vapor generation which you would get in the expansion chamber would have to be vapor generation as a result of cracking, would it not?

A. Assuming there is no pressure drop from the transfer line to the expansion chamber, yes.

Q. Why do you qualify it?

A. Because there might be a pressure drop between the transfer line and the expansion chamber which would cause further vapor generation as the material entered the expansion chamber.

Q. But the patent says "delivered in liquid phase to the expansion chamber."

A. No, the patent does not say "delivered in liquid
1534 phase." It says the material is delivered in substantially liquid phase through the transfer line.

Q. By the words of the patent, delivering it in substantially liquid phase to the expansion chamber, would you consider that would mean any real amount of vaporization?

A. Well, it means from 25 to 30 per cent vapor generation anyway, because that is what happens in that example.

Q. That is the way you understand "substantial"?

A. That is what happens in that example.

Q. Now, according to the teachings of the Egloff patent would it be advantageous to return some of the reflux to the charging coil to mix with the charging stock in the travel through that coil?

A. Do you mean in coil 5?

1534 1171 Q. Yes.

A. No, there is no such teaching in the patent.

Q. Well, would there be any advantage in doing that?

A. Do you mean do I think that there might be some advantage?

Q. Yes, right.

A. Do you want me to make another invention, or
1535 something or other?

Q. No, I am not asking you to make any invention. I am asking you to return some of this reflux to the charging stock or charging coil. Would there be any advantage in that?

A. I can see no advantage in it under the teachings of the Egloff patent.

Q. Why do you say that?

A. Well, I just don't see any advantage in it. That material is heated to a higher temperature in coil 6, and that is specifically what he wants to accomplish. As he says, page 1, beginning line 15:

"The object in the present instance being to subject the reflux condensate to different conditions of temperature or pressure or both than that to which the raw oil is subjected."

Now, if his object is to subject the reflux condensate to different conditions of temperature or pressure or both than he does the raw oil, he certainly wouldn't want to put the reflux condensate in the coil with the raw oil and subject it to the same conditions of temperature and pressure.

1537 1172 Q. Dr. Brown, when you gave me that 35 per cent vapor generation in the expansion

chamber, you assumed a certain length of coil and size of expansion chamber, did you not?

A. I was taking the expansion chamber, I think, as given in the drawing of the Egloff patent, or rather as stated in the text of the Egloff patent, where he says it may be, for example, 68 inches in diameter and 40 to 60 feet long. And let's see, I took a chamber which had about 1270 cubic feet.

1173 *Redirect Examination by Mr. Hall.*

1540 In my cross-examination referring especially to PX 511 I was asked if a pressure valve was put in the transfer line between the B tubes and the C tubes, would it be possible to operate without substantial vapor formation in the B tubes, and I answered "yes." I thought the question asked me was whether it would be possible to operate without vapor generation and I said "yes", and I assumed that the pressure built up in the B tubes would probably be about
1541 2000 pounds or upwards under the conditions that correspond to the type of reflux and charge as used in the example that we were discussing.

Referring to the answer that I gave in respect to the operation of the process of the Dubbs patent as exemplified by PX 511 or the process I described in connection therewith, I considered the minimum temperature conditions given in the illustrative run of the Dubbs patent, which is found on page 2, and a pressure of 100 pounds with gas oil as the charge,
1542 and I can state that the ultimate gasoline yield of such a run based on the charge would be about 35 or 36 percent, of which about 10 percent would be produced by cracking in the B tubes and the balance in the C tubes.

Referring to the same process carried on in the still exemplified by PX 511 and with the same gas oil charge, but instead of using the minimum oil temperature which is given in the illustrative example I will use an oil temperature of about 850°F., which is ten degrees below the maximum oil temperature as given in the illustrative example, I will say that the gasoline yield will be about the same, that is, 36 or 38 percent, of which about 30 to 40 percent varying with

1543 the through put would be made by cracking in the B tubes.

1543 1174 The effect of this increase in oil temperature on the velocity of oil passing through the B tubes is that it would permit a greater throughput, which would increase the velocity, and because of the greater temperature at the same pressure with the same gas oil charge there would be greater vapor generation, which would also increase the velocity of the oil through the B tubes.

Referring to the Egloff patent in suit, I will describe where the primary cracking of the reflux occurs based on the teachings of the patent. The teachings of the patent are clear as stated on page 1, beginning
1544 line 15, "the object in the present instance being to subject the reflux condensate to different conditions of temperature or pressure or both than that to which the raw oil is subjected", which is again stated after the example toward the lower right-hand corner of the page, page 1, beginning line 103: "It will be thus seen that the reflux condensate is continuously subjected to recracking, but at different conditions of temperature or pressure or both, than that to which the raw oil is subjected."

The only place in the apparatus or process in which the reflux condensate can be cracked under different conditions of temperature or pressure than the raw oil is in coil 6, as that is the only place in the process in which the reflux condensate is subjected to a cracking temperature out of contact with or not intermingled with the raw oil. Therefore it seems clear
1545 that the teaching in the patent is that the major cracking of the reflux condensate must occur in coil 6

1545 1175 On cross-examination I was asked to produce dictionaries giving the word "vaporization," the meaning I ascribed to it in its setting in the Dubbs patent in suit. I have here a couple of dictionaries or photostatic pages from them. The Century Dictionary and Cyclopedia by The Century Company gives a dictionary definition for the word "vaporization" which is, "The act or process of vaporizing." You go down to the word "vaporize" to see what is meant and we find two definitions for
1546 the word "vaporize". The first one is for the transitive verb, "to convert into vapor by the applica-

tion of heat, reduction of pressure, or other means; cause to evaporate", and a second definition given for the intransitive verb, "to pass off in vapor; as, sulphur or mercury vaporizes under certain conditions", which gives the two definitions one of which means the generation of vapor and the other one the separation of the material in the form of a vapor from a liquid or solid.

Another smaller dictionary, Macmillan's Modern Dictionary, the words "vaporize", "vaporized" or "vaporizing", gives for the transitive verb, "turn into or cause to pass off as vapor as by the application of heat," giving the same definition but giving the definition for the transitive verb that the Century Dictionary gave for the intransitive verb.

Then there are a couple of references from physics books of a similar nature to those which Mr. Thiess showed me the other day, one from Elements of Physics by Professor Hoadley of Swarthmore Col-
1547 lege, which gives a chapter or section on vapor-
1547 1176 ization. The paragraph 302 on page 237, under the title "Vaporization" describes the operation as follows: "As the molecules of water (or ice) in their vibration strike against the surface, many of them force their way through it and pass into the air where they exist as molecules of water vapor. When heat is applied, the temperature is raised, which means that the velocity of the molecules is increased; and the number of molecules that pass into the air increases with their velocity. As long as the temperature is below the boiling point, the process is called evaporation." Which is an explanation of the action of vaporization in which the molecules pass away from the mother substance or the water and exist as vapor in the separated state or in the air.

Another explanation of "vaporization" from the book Physics for Colleges by Sheldon, Kent, Miller and Paton, 1926, VanNostrand Company, under the heading "Vaporization", in the second paragraph of
1548 Chapter XX on page 168, showing a figure representing molecules within the liquid and describing how the molecules escape from the liquid:

"Consider Fig. 20.01. Here, molecule A has as many of its kind pulling it up as pulling down, so

that it has no tendency to move in any particular direction. It is balanced on all sides. Molecule B, since its sphere of action extends beyond the surface, has fewer pulling it up than down, and C is in the extreme position of having no forces whatever pulling it up out of the liquid as there are no molecules above the surface, or if any, they are too far apart to count, comparatively.

1548 1177 "It would seem then that a molecule would have small chance of escaping from the surface against such odds, but occasionally one will do so because of acquiring a velocity considerably above the average, by a series of lucky impacts in the proper direction. Thus, molecules of liquid vaporize, as we say, and above a liquid vapor will always be found because of this action," which in the same paragraph describes "vaporize" as escaping.

1549 Then from an engineering text which is widely used in industry and in the universities, Principles of Chemical Engineering, by Walker, Lewis and McAdams, First Edition, 1923, published by McGraw-Hill Company, Chapter XII, Page 375, under the title "Basic Principles of Vaporization Processes", the second paragraph:

"Industrial terminology distinguishes three cases in which separation is accomplished by utilizing differences in the volatility of substances." So that the whole section here deals with separation processes and under "Vaporization" he describes three different separation processes.

"Evaporation is the removal by vaporization of a portion of the solvent from a solution of a solid or a practically non-volatile liquid, when the vapor formed is valueless."

Then the next type of separation by vaporization is classified as distillation. "Distillation is the removal by vaporization of one liquid from another when the vapor is of sufficient value to warrant recovery by recondensation."

1549 1178 On the next page, the first paragraph, "When
1550 one solid is separated from other solids by vaporization and subsequent condensation the process is spoken of as sublimation."

The second paragraph, "Drying is the removal, generally by vaporization, of one liquid from another

liquid or from a solid." Then an explanation is given of the mechanism of vaporization which is very similar to that given in the physics texts. It starts at the bottom of page 376 and runs over to the top part of page 377:

"The molecules of a liquid are considered to be in a state of constant unordered motion, some moving with great velocity, while others move relatively slowly. For any temperature, however, there is a certain mean velocity of the molecules, which for temperatures below the boiling point of the liquid, is not sufficient to project them beyond the free surface of the liquid. But there are always some molecules which possess a velocity sufficiently greater than this mean, that, when they approach the free surface of the liquid, they overcome the mutual attraction exerted between them and other molecules in the liquid, and continuing their motion, pass out
1551 into the surrounding space, "which I think clearly indicates that the word "vaporization" is used to include processes of separation by vaporization. Much the same language was used in some of the references referred to me by Mr. Thiess.

In my cross-examination I referred to a foam in the tubes in the high temperature section of defendant's furnace, and to some testimony I had seen in Gasoline Products Company *vs.* Champlin Refining Company, to the effect that when the stream
1551 1179 leaves the high temperature coils 99 percent of the stream is in vapor phase and notwithstanding the stream as a whole is in a foamy mass.

I think I referred to both the opinion and the record. The opinion was read in court the other day and this is a statement by Mr. DeFlorez:

"I think that regardless of what might happen by some mechanism outside of the coil, that the phases as they exist inside this system would remain
1552 mixed. I don't believe that they would under any circumstances separate out in the transfer line or along the tubes."

1553 Provided the length of the coil 6 in Egloff is adequate one can do the major part of the cracking of the reflux in coil 6 under the conditions set forth in the illustrative example of the patent.

1180 *Recross Examination by Mr. Thiess.*

1554 The Witness: You asked me to give you the relative times that the material would be in coil 6 and in the expansion chamber of Egloff. And also then using about eight or nine hundred feet of pipe in coil 6, as we were discussing the other day. The approximate time that the reflux condensate would be in coil 6 under the operating conditions we were discussing would be about twenty minutes, and the average time that the material coming from coil 6 would be in the expansion chamber would be about four or five hours. Some of it would be in much less than that, of course, and some would be in a little longer.

Q. Supposing you had a three-hundred-foot coil instead of an eight-hundred-foot coil or nine-hundred-foot coil, what would those figures be?

A. Well, it would be proportionately less. The time would be reduced approximately in proportion to the length of the coil. If it was three hundred
1555 feet it would be about one-third as long as that, and if it were 1800 feet it would be about twice as long.

Q. You have referred to the Egloff patent in your redirect, to the statement occurring in the last paragraph of column 2, page 1, and you stated after reading that statement that the major cracking would therefore occur in coil 6. There is no statement in the patent that the major cracking occurs in this coil 6, is there?

A. Except in those two statements which I
1555 1181 read, which clearly state that he is going to crack the reflux condensate under different conditions of temperature or pressure, or both, than that to which the raw oil is subjected.

Q. He says he is going to crack it but he doesn't say that the major cracking is going to occur in coil 6, does he?

A. If he is going to crack, that is where the cracking takes place.

Q. The cracking also takes place in the tank, does it not?

A. Yes, but you would have different conditions

1556. of temperature and pressure for the reflux condensate than for the raw oil.

Q. But there is no statement that the major cracking in the system is going to occur in coil 6, is there?

A. Except the teaching in those two paragraphs which I have just read, which to me clearly indicates that the cracking of the reflux condensate must take place at a place in the process where the temperature and pressure is different than that to which the raw oil is subjected.

From that statement I deduce that Egloff teaches that the cracking of the reflux condensate occurs primarily in coil 6.

Q. Now, on this question of vaporization, Mr.
1557 Brown, don't you have a liquid surface when you have a vapor bubble formed, as truly as you do when you have a flat horizontal liquid surface?

A. Yes, there is an interface between the liquid and the bubble.

1558 The pressure would be below 660 pounds at the outlet of the defendant's third bank. I think approximately 9 per cent by volume gasoline is produced through this third bank.

1558 1182 Q. Now, if the material flowing in defendant's coil was discharged from the outlet of the third bank to a reaction chamber could not an operable process be made at a lower pressure than the 2,000 pounds you have mentioned?

A. But there is vapor generation at the outlet of the third bank.

Q. Well, isn't there a place in that third bank where gasoline is formed where you don't have any vapor generation?

A. There may be. I am not sure.

1559 Q. You don't know?

A. There may be at the entrance to the third bank. I don't know how much gasoline would be there and I don't know what the pressure is. There might be.

Q. Well, it would be below 660, would it not?

A. Yes, there would be no point in the furnace where the pressure would be above 660 pounds.

Q. So that the oil could be transferred from that point where it was all in liquid condition to a

reaction chamber at a pressure under 660 and operate the process without vapor generation in the coils?

A. Well, I had in mind when you were asking, Mr. Thiess, some kind of practical operation.

Q. Well, you don't think that would be a practical operation?

A. Well, if you will give me the conditions I will form an opinion on it. I don't quite know what you are talking about now, what temperatures you have there, how much gasoline you have or anything else.

1559 1183 Q. You have got a temperature of 910 at the outlet of the third bank?

A. That is right.

Q. Now, you would have a temperature in the
1560 neighborhood of 900 degrees and a pressure under 660 prevailing in the third bank?

A. At that point.

Q. At that point?

A. That is right.

Q. Now, you would have substantially that temperature and that pressure in that third bank without vapor generation, would you not?

A. No, there is vapor generation according to the stipulation, about 90 per cent by weight liquid, so there is 10 per cent vapor generation.

Q. All right. Going back to the tubes where you did not have that vapor generation, you would be close to the 900 temperature figure, would you not?

A. Well, going into the third bank the temperature is given as 725.

Q. Well, now, would you say that vapor generation occurred at that 725 figure?

A. I think not.

Q. Would you say it occurred at an 800 degree figure?

1561 A. Do you mean in that third bank?

Q. Yes.

A. Oh, I don't know.

1561 1184 Q. Well, now, let us take the 800 degree figure and transfer that oil to a reaction chamber carried at the same pressure. Wouldn't you have a useful and operative process?

A. Yes, you would.

Q. And wouldn't you be operating under 2,000 pounds?

A. Yes, but you have no valve in the transfer line.

Q. Well, I am not talking about a valve in the transfer line. Well, let us put a valve in the line and let us reduce the pressure from 600 pounds to 200 pounds. Wouldn't you have an operative process?

A. Cracking process?

1562 Q. Yes.

A. Let's see; 800 degrees. You drop to 200 pounds. Well, I don't think that would be a very satisfactory cracking process.

Q. That is your well considered opinion, is it?

A. No, it is a rather curbstone opinion right now. I haven't had a chance to go into it. My reason for that is that when you drop that pressure to 200 pounds, why there is going to be a good deal of vapor generation and vapor liberation, which will be accompanied by an appreciable drop in temperature, and the only appreciable time that the material would be at an active cracking temperature would be in the tubes. Now, I haven't gone into it but I doubt very much if such an operation would be particularly satisfactory as a cracking operation.

1563 1185 Mr. Thiess: Q. Now, just another question, Mr. Brown. When you gave this 2,000 pound pressure you based that on some character of charge in the reflux, is that correct?

A. Yes. Of course the pressure necessary to suppress vapor generation depends upon the temperature and the character of the material in the tubes.

Q. What is the character of reflux that you assumed when you got that 2,000 pounds pressure?

A. Well, I was taking the general character as would be found in these Dubbs plants, such as these 500-barrel plants or the plants that we have been discussing.

Q. Well, they didn't know about the reflux ratio
1564 in those plants, did they, at the time when they first started to operate these?

A. Well, they had only a fair idea, but that doesn't have anything to do with this answer, Mr. Thiess. Whether they knew or not what the reflux ratio was doesn't make any difference.

Q. Well, did they know what the reflux was, the character of the reflux?

A. Well, by direct feed you can get a direct sample of it, and you can get a sample of the combined feed very easily from those plants.

Q. Can you give me definitely what type of reflux you used in getting this 2,000 pound pressure? You made some calculations, didn't you? You must have used some type of reflux.

A. The character of the material going through the tubes would determine the pressure required to suppress vapor generation as well as the tem-
1564 1186 perature. They are all interrelated, and I know that in many cases it is necessary to go as high as 2700 to 3000 pounds in order to suppress vapor generation in cracking furnaces, and it will vary. I estimated about 2000 pounds for the approximate type of material that would be sent through these
1565 tubes in the Dubbs plant. Now, if you care to give me the temperature and character of stock, and so on, I can figure out approximately what pressure would be necessary. They are all interrelated and I don't want to be anchored to 2000 pounds pressure. It might be necessary to go to higher pressures and in other cases you might get by with somewhat less than that.

Q. Then that 2000 pound pressure was not anything that you calculated?

A. No, I made an estimate, Mr. Thiess.

1187 *Redirect Examination by Mr. Hall.*

1565 In the process to which my attention was just called on recross examination, at 800 degrees and some indeterminate pressure below 660, the amount of cracking in the tubes would be very small.

1566 In the operation which I considered involving a pressure of 2000 pounds I assumed more cracking in the heating coil than would take place at 800° and 660 pounds.

DEFENDANT'S CASE.

1189 DR. H. P. CADY:

Direct Examination by Mr. Von Holst.

1581 My name is Hamilton Perkins Cady. My residence is Lawrence, Kansas, and I am sixty-six years old. I am Professor of Chemistry and Chairman of the Department of Chemistry at the University of Kansas. My other training and qualifications are as follows:

I graduated at the University of Kansas in '97 with the degree of A. B., and was a Scholar and Fellow in the Department of Chemistry in Cornell University in the years '97-'98, '98-'99, and then went back to the University of Kansas as Assistant Professor
1582 in 1899; took the degree of Doctor of Philosophy at the University of Kansas in 1903, and I have been connected with the chemistry department of the University of Kansas ever since '99.

I have, of course, carried on various lines of research in chemistry; and during the war I served as chemical engineer for the Bureau of Mines in the development of the process for the extraction of helium from natural gas.

I have a patent for a machine for the very precise and very rapid determination of molecular weights of gases and vapors that is proving very useful in connection with the distilling industries and the analysis of mixtures of gases and of vapors, and I have a number of other patents.

I am a member of the American Chemical Society; have been past chairman of the Kansas City
1582 1190 Section of the American Chemical Society. I was a member of the National Research Coun-
1583 cil, and have been one of the counselors of the Chemical Society for a good many terms. I am a life member of the Kansas Academy of Science, and a life member of the Sigma Psi scientific honorary fraternity. I have been a member and Fellow of the American Association for the Advancement of Science, and I am a past vice-president of the Chemistry Section of that organization.

The so-called physical states of matter are solid, liquid and gaseous.

A substance is a solid if the given body composed of it has both definite volume and definite shape, independent of its surroundings.

A substance is a liquid if a given weight of it has definite volume but takes its shape from the surroundings in so far as it can fill them. If you put some of a liquid into a container, it will fill that and run down to the bottom, leaves a free surface which is approximately flat compared with the surface of the earth. If the body of the liquid is small and is
1584 free from the surroundings, it takes on the form of a drop more or less—a sphere, more or less modified by the action of gravity.

A substance is gaseous if a given weight of it has neither definite volume nor definite shape but spreads through and fills any container that you put it in, and takes on the shape of that container.

1585 Gases have weight as can be demonstrated very easily by exhausting a flask, filling it with oxygen, weighing it, noting the weight of the flask filled with oxygen, again exhausting the flask, refilling it
1585 1191 with carbon dioxide and again weighing it. It
1586 will be found that the flask filled with oxygen
1587-8 weighed 3.1 grams, and the same flask filled with carbon dioxide weighed 4.2 grams.

As to what is the generally accepted fact of the structure of matter, I think everyone is familiar with the idea that everything is made up of extremely minute particles called atoms, or aggregations of these atoms that are called molecules. These particles are so small that even our most powerful microscope will not enable us to see them, and consequently,
1589 we define a fact, as I have been doing to my students for many years, in this way; a fact is the direct result of observation unmodified by any act of reason. We define a fact that way since we cannot see these molecules or atoms, cannot directly observe them. I cannot say that it is a fact that atoms and molecules exist, but there are thousands upon thousands of facts which can best be explained to our reason on the assumption that atoms and molecules really exist, and I do not know of a single fact that shows that they do not exist. Consequently, I, and I think almost everyone else, constantly talk about them as though they were actualities.

There is a way in which we can arrive at a helpful conclusion as to the relative weights of the hypothetical molecules of gases. Something like 130 years ago—to be more precise, in 1811—an Italian scientist whose name was Avogadro, put forth what proved to be a very useful hypothesis. He made the hypothesis that equal volumes of all gases under the same conditions of temperature and pressure contained
1589 1192 the same number of molecules. You see you cannot establish that in fact, because you cannot count them. He made that guess, and it has proved very helpful indeed.

1590 Now, we can assume this, we take this data, the rough data we have got here, and make an approximate calculation as to the relative weight of the single molecules of oxygen and carbon dioxide. You can see that readily enough.

Because, according to Avogadro's hypothesis, this flask full of oxygen and a flask full of carbon dioxide would contain the same number of molecules, whatever that number was. Then the weight of the flask full of oxygen is to the weight of the flask full of carbon dioxide as the weight of one molecule of oxygen is to the weight of one molecule of carbon dioxide. Chemists and physicists have for a long time taken oxygen as the standard for these relative molecular weights, and have given to it, rather arbitrarily but with good reasons for it, a relative weight of 32. Then you see we can set up here the 3.1 grams of oxygen as to 4.2 grams carbon dioxide, as 32 is to X, and we would have the weight from our approximate determination of a single molecule of
1591 carbon dioxide relative to a single molecule of oxygen, of 32. That would calculate out, if you gentlemen have a slide rule, approximately about 43 and I think 4/10. The very precise determination gives the ratio almost exactly 32 to 44, so the rough balance did not miss it so very far.

A gas exerts pressure upon the walls of a vessel containing it. Equal volumes of different gases produce the same increase in pressure when added to a given vessel, temperature and pressure remaining constant.

1600 1193 Dalton's law of partial pressures, which he gave the world approximately 130 years ago,
1601 may be worded something like this: Each gas in a gaseous mixture spreads through the entire mixture —some use the word "pervades"—through the entire mixture and exerts the pressure which it would have exerted had it alone been occupying such space of the mixture. And each one of these gases has its own individual pressure, called its partial pressure, and the total pressure of the gas is the sum of these individual partial pressures.

1602 Temperature influences the pressure exerted by gas.

Substances change their physical state. A solid will become a liquid, and liquids will become solids and sometimes vapors. Solids will become vapors. They change their state very frequently. Everybody knows that if you raise the temperature of a solid it has a tendency to pass into the liquid state. Ice melts. If you raise the temperature of either a solid or a liquid, it tends to change into a vapor. Water boiling forms steam.

The formation of a vapor from a solid can be
1603 demonstrated very easily with the use of iodine whose vapor is a violet color. The iodine itself is a dark gray. If iodine is put in a closed vessel, the violet color of the iodine vapor is perceptible, and if the temperature is raised the vapor becomes much more apparent.

The formation of vapor from liquids can be easily demonstrated. We can take a vessel containing some bromine. Bromine is a liquid at ordinary temperature, a dark reddish brown in color, easily volatile and so easily volatile that in a sealed container with some bromine in there, there is no difficulty at
1603 1194 all about seeing the reddish brown vapors of the bromine.

1604 The change of state from a liquid or solid to vapor is called "vaporization". The word has had that meaning to me ever since I have had anything to do with science, which is considerably more than fifty years. The word "vaporization" standing alone, has a definite meaning which is the change of a liquid or solid into a vapor.

As to the generally accepted explanation of the

mechanics of vaporization, going back to our theory that atoms and molecules exist, solids and liquids would be composed of molecules of substances, and these molecules are, apparently from all the behavior of the things, in rapid motion in all sorts of directions. These molecules come to the surface, and some of them will be moving fast enough so that they escape from the surface and go out into the surroundings; and as soon as they have done that, they become perfectly free to move in all directions, take on the shape of their surroundings, they become
1605 gaseous to all intents and purposes, and are vapors. Now these molecules in their random motion in every direction, some of them will come back and hit the surface of the solid or liquid and hit it hard enough so some of them will pass back into the solid or liquid and become solid or liquid as the case might be. So that this process of vaporization is reversible, some of them go in one direction and then in another. All such processes as that tend to come to a condition of balanced action, a condition of equilibrium when as many molecules of vapor will be formed in a second as are changed back into the solid or liquid, as the case might be, in the same time. When that happens we say that the vapor is in equilibrium
1605 1195 with the liquid or solid.

The vapor pressure of a liquid or solid is the gaseous pressure exerted by the vapor of that liquid or solid when that vapor is in equilibrium with the
1606 liquid or solid. The vapor pressure depends upon the kind of substances that you are working with, and the temperature. It does not depend upon the absolute or even relative quantity of the liquid or vapor phases, or the condition of these unless the liquid be in very small drops or the solid in very fine powder; then there is a slight difference.

Rising temperature invariably increases the vapor pressure of the liquid or solid and does it very rap-
1607 idly. The vapor pressure of a liquid can be readily measured. This can be demonstrated on DX 641 on which are two tubes labeled C and A. Tube A is a barometer for the bulb at the bottom is open to the air and the mercury measures the pressure of the air in the room. Tube C is similar to tube A except
1608 that the bulb is sealed off. In the bulb is water and

above the water is apparently empty space, but that space is not empty, it is filled with this gaseous water that has been formed from the liquid water by this process of vaporization. The difference in the level between the mercury in the tube, bulb C, and the mercury at the point J will measure the pressure exerted by the—the gaseous pressure exerted by the pressure of the water first upon the liquid water and then through that liquid water upon the mercury, pushing the mercury up just as the oxygen and the carbon dioxide, and so forth, of the earlier experiment pushed the mercury up in the tube.

1608 1196 On DX 641, the condition of the mercury in the column C is shown when the water in the beaker is boiling. If the water were cold in the beaker and therefore the water in the tube C would 1609 be cold, the mercury shown at the point J on DX 641 would move down until at room temperature it would be a little less than an inch above the mercury in tube C.

As the water is heated the temperature of the water rises in the bath D around this, the water inside the bulb C would be heated, vaporization would take place faster, there would be a greater accumulation of molecules of water in bulb C, consequently a greater pressure. The greater accumulation of molecules the greater weight of water. The pressure would be greater and the point J would move upward, at first relatively slowly and then toward the last quite rapidly. I am thinking now for a given rate of rise in temperature of the water around the beaker. We can measure the temperature of the water in that beaker by the thermometer which is represented by T. If you wish you could make a careful record of the pressures, vapor pressures of the water at each of these temperatures as you went up and then be able to represent these, this data in the form of a curve.

1610 I made the curve and it is shown on the chart, DX 642. This curve we obtain by measuring the vapor pressure of water at a variety of temperatures as you raise the temperature of the water in the bath D. You see the pressure measurement of the mercury plotted up one side and the temperatures in the other direction. You can see from the shape of this curve

how rapidly the vapor pressure rises as the temperature rises, it rises more rapidly than the tem-
1611 1197 perature. Now water is simply a typical liquid; all other liquids behave in the same sort of way. Each and every one of them gives a vapor pressure and in each case the vapor pressure increases more rapidly than the temperature, so we always get a curve that is concave upward.

Now, as we continue to apply heat to the water in the beaker D, the temperature will rise and finally it will begin to boil, and when it is boiling that condition is supposed to be represented on this drawing by these little circular bubbles.

When the water is boiling, we find that the temperature remains constant, shown by the thermometer.
1612 The vapor pressure of the water in the tube C will also remain constant. You will have no rise of mercury, it would be up at point J.

If we had the actual apparatus before us we would find that the height of the mercury in barometer A and in the vapor pressure measuring tube C were perfectly identical.

In the bath D, bubbles of vapor would be forming in the bottom of the beaker and would rise through the water, burst at the top and go off into the air.

In the tube C we would be unable to observe at any time during the heating of the bath D the formation
1613 of bubbles. The vaporization in the tube C would take place from the surface of the liquid, surface of the water. In this other case the vaporization is taking place down at the bottom of the beaker where the heat is entering the bath from the burner that we have down below. And those bubbles of vapor which are formed by the absorption of heat from the burner rise up through the liquid and burst at the top.

Now those bubbles are filled with water vapor,
1613 1198 and your reason would readily tell you that that water vapor would have to be under pressure, pressure of air upon the surface of the liquid in the beaker, and a little additional pressure, the little additional pressure being due to the weight of this column of water. So the water in this beaker would have to be heated to such a temperature, before it would really boil, that the pressure was equal to the pressure of the air which is measured by your

barometer, plus the hydrostatic pressure of this column of water over it.

1614 Referring to DX 641, in bringing the water in the beaker D up to the boiling temperature, the heat is being consumed in raising the temperature of the water, the specific heat would be of the water and the heat capacity of the beaker and all the things in there would be the things that consumed the heat.

When boiling begins in the beaker D, we have quite a different process going on there. We have the change of the liquid water over into gaseous water, water vapor, and that is accompanied by the absorption of a very considerable amount of heat, very large in comparison with what is required to raise the temperature of your water. In fact to evaporate a pound of water, to vaporize a pound of water, change

1615 it from the liquid into the gaseous state will require as much heat as would be used in raising the temperature of more than five pounds of water clear from the freezing point of the water up to the boiling point; 5.4 pounds to be exact were the portions. The temperature of steam will not be the least bit higher than that of the water from which it is formed.

1615 1199 In physics, that heat is called heat of vaporization, sometimes latent heat of vaporization, but most generally heat of vaporization. As to how long it has been called that to my knowledge, it is pretty hard to find when some of these terms first came into use, but I found it used just that way in Cook's Chemical Philosophy, printed in 1860, which means it has been in use for 80 years; and a similar term has been in use since 1767 when Joseph Black, a Scotchman, studied the phenomenon. He called it "latent heat".

1616 The boiling point of a liquid is the temperature at which the vapor pressure of that liquid is equal to the external pressure. A liquid has many boiling points, almost infinite number of boiling points because the external pressure can vary over a wide

1617 range. The normal boiling point of a liquid is the temperature at which the vapor pressure of the liquid would be equal to the standard atmospheric pressure of 76 centimeters or 760 millimeters in mercury. The normal boiling point of a liquid is a very characteristic property of the liquid. It helps materially in

identifying the liquid, distinguishing it from other liquids.

1618 Pressure has a very marked effect upon the boiling point of a liquid as can be demonstrated very easily.

1623 We can in a comparatively short time so change the boiling point of the water by a mere change of the pressure upon it that we will have in one case the water boiling at a higher temperature than the normal boiling point of water, higher than 212 Fahrenheit, and in other cases low enough so that it will freeze. That means 32 degrees.

1624 1200 The freezing of the water as the pressure has decreased is caused by the lowering of the temperature due to the absorption of heat when the water undergoes this process of vaporization, that is changing from the liquid into the gaseous state, a very considerable absorption of heat.

The photograph, DX 644 represents a long tube. The tube is a glass tube. It is approximately five feet long and two and one-half inches or so in diameter. That is filled with distilled water within a few inches of the top of the tube as we set it up. Now, the water in this tube, when this photograph was taken, had been heated for some little time by the

1625 burner shown at the bottom on the ring stand.

The water had been heated by this burner and at the moment the photograph was taken the water was boiling vigorously in the bottom of the tube. The bubbles filled with water vapor were rising through the tube for a considerable distance, approximately half the length of the tube. You can see the upper bubble about half way up, and there the bubbles were condensing back to liquid water and disappeared. At no time did the bubbles rise clear to the top of the tube.

We had a process of vaporization going on in the bottom of the tube, the formation of vapors of water from the liquid water at the point where the heat was

1626 entering the tube. These bubbles rose through the water due to the difference in density of the water vapor and the liquid water around them. After they had risen a little ways they commenced to condense, turning back to liquid water again, the opposite of the vaporization process, and giving up to the sur-

roundings the heat of vaporization as they con-
1626 1201 densed. By the time they got approximately half way up the tube they had all disappeared and gone back to liquid water again.

The phases that are present in that tube are liquid water and water vapor.

The photograph, DX 645, shows the same tube, taken just a few moments later after removing the burner from the bottom of the tube.

1627 Now, the point to this is that if you will compare the position of the upper surface of the water in this tube with that in the preceding photograph you will see that the upper surface now is further from the top of the tube in DX 644 where no boiling is taking place. Now the difference in the position of that will be a measure, very obviously, of the volume occupied by the water vapor in the first photograph.

I will now explain how the vapor pressure of two different pure substances compare at the same temperature and will also discuss the effect of the presence of each of these substances upon the vapor
1628 pressure of the other when these substances are dissolved in each other, but first, I must define the word "solution". A solution is a homogeneous mixture of two or more substances the relative proportions of which can vary continuously within wide limits and whose properties are a mean or average of the properties of the components, taking into account their relative proportions.

1631 Referring to DX 646, we have a group of four of these tubes adapted to measure the vapor pressure of liquids. In tube A we have not water this time but another liquid, octane, pure octane.

1631 1202 In tube D we have pure heptane, and in tubes B and C we have solutions of octane and heptane in each other.

1632 In tube B we have a solution which we made purposely so that one-third of the molecules in there should be heptane and two-thirds octane, and in tube C we have one in which we purposely made it so that two-thirds of the molecules should be heptane and one-third octane.

Now, we have a long trough, indicated here, filled with water which can be heated to boiling. That will give us a uniform and pretty constant temperature

throughout the whole, uniform over the whole thing and constant dur[illegible]g our experiments, and each one of these tubes then will be heated equally to the same temperature, the temperature of boiling water.

We can with this device then measure the vapor pressure of octane or heptane, each in the pure state, in the same way we can measure the vapor pressures of the solution of heptane and octane of these two different compositions.

Now, the first thing that we would notice on this is that at one and the same temperature the vapor pressure of our heptane is materially greater than that of the octane, as shown by the greater height of the mercury column that supports it, in the case
1633 of the heptane and the octane.

May I say, your Honor, that this chart is prepared from the actual apparatus that we have set up and prepared for this and represents it truly.

Now, in a similar way, the height of the mercury in the tube B, the one containing the mixture of octane and heptane, one-third of the heptane, will meas-
1633 1203 ure the vapor pressure of the mixture of octane and heptane vapors that are contained in there, and the height of the mercury in the tube C will measure the vapor pressure of the mixture of the octane and heptane vapors in the tube C.

Now, this shows, in the first place, that the octane and heptane have quite markedly different vapor pressures. That is very evident.

These mixtures are homogeneous. They are made of octane and heptane. These may be mingled in any desired proportions for they will mix in all proportions from 100 per cent of one to zero per cent of the
1634 other, infinitely soluble with one another.

This solution of the octane and heptane in tube C would show the properties of octane and the properties of heptane to a degree that corresponded to the properties of each one of them in there.

1636 If we draw a straight line between the points A and D, A representing the vapor pressure of our oc-
1637 tane and D that of heptane, and locate as we have done in our apparatus the tubes B and C at the proper distances between the A and D, the tube B one-third of the distance from A to D and the tube C one-third

of the distance from D to A, you see these mercury surfaces at B and C fall on that line.

Supposing we should keep our heptane but change the octane to some other hydrocarbon, some other hydrocarbon than octane, one that had a lower vapor pressure. If you glance back at the diagram you will see that the point A for our new hydrocarbon would lie at a lower point than A does for octane if our new hydrocarbon that we chose was less volatile than our octane.

1637 1204 Now, it wouldn't be hard to select a hydrocarbon which, at the temperature of boiling water, would have virtually no vapor pressure. Then the point A would move down so that it would coin-
1638 cide with point E near the bottom of the diagram.

In every case, down to and including that, vapor pressure of mixtures of heptane and octane or heptane and this hydrocarbon would lie on a straight line drawn from this movable point between A and E to the point D, and in the limiting case where the hydrocarbon is practically non-volatile the vapor pressures of the mixtures would lie on the point ED. The only volatile constituent in there would be, under these conditions, the heptane, and the vapor pressure of that mixture would be due to the heptane alone, and that would be the vapor pressure of the heptane, taking into account the relative proportion. If it is one-third the molecules in there the vapor pressure of the heptane from that mixture would be one-third of the vapor pressure of pure heptane; if two-thirds, it would be two-thirds of the vapor pressure of pure heptane.

Now, we could change from our heptane and go back to the octane. If the octane were here and change our heptane into a less volatile hydrocarbon, and as a limit one that was not appreciably volatile, the line
1639 that would represent the vapor pressures of mixtures of octane and this non-volatile hydrocarbon would lie on the line AF. You find F over there (indicating).

And for a mixture that was one-third in its molecules—a mole fraction is the technical term you have doubtless heard many times and a mole fraction is

one-third—the vapor pressure of that solution
1639 1205 would be rep- sented by the point O on here and is one-third of the vapor pressure of octane. And for two-thirds octane it would be the point N.

The point O, the line OG—the length of that line
1640 would represent the partial pressure of the octane in this mixture, and the length of the line HN—you see H one the base line right under N—would represent the partial pressure of the octane in that mixture.

Coming back to our heptane mixture, the length of the line GI—I am looking at the one that is one-third octane—the length of that line would represent the partial pressure of the heptane from this mixture that is two-thirds heptane, and the line GO represents the part down toward the bottom which is the partial pressure of the octane in that same mixture.

Now, from Dalton's Law of Partial Pressures the total pressure should be the sums of these two separate individual pressures. We could get that by taking this distance OG and bringing it up to the point I, and laying it on there. Then we find it would bring us right to the point C, showing that in this case
1641 the total vapor pressure of the solution of octane and heptane is equal to the sums of the individual vapor pressures of the constituents, each constituent in there showing its own properties modified by the portion of it present.

In not all cases of solutions would you have the thing come out as well as this. This has been found to hold years ago by a man by the name of Raoult, and he expressed it in what is known as Raoult's law that is used very much. It is a very useful description of the way nature works. That is what these laws are.

1641 1206 But this law works very well when you are dealing with solutions of similar substances, ideal solutions, as they are often called, but if you bring together dissimilar substances then they will either exhibit unusually great likings for each other
1642 or something of a dislike for each other, and this line that corresponds to the line AB will not be as straight a line. It will curve up or curve down, as the case may be.

Sometimes in some solutions you will find that line dropping below the least volatile or going up above

the most volatile, and with great increases of pressure such as you have sometimes, you will have deviations. But this is nature's ideal.

This principle that I have explained has application in the process of fractional distillation. Let us refer to this diagram again and let us concentrate our attention for the moment on this tube C over here. Now, the partial pressure of the heptane in here is measured by the length of that line GI, and the partial pressure of the octane in there is measured by the length of the line GO.

Or we could think of the octane as supplementing that of the heptane. Then it is the length of the line
1643 CI, that distance up there (indicating).

Now we learned from Dalton's Law of Partial Pressures that the pressure exerted by a given quantity of gas was the measure of the number of molecules of the gas that we have present per given volume, per constant volume. Now, if we look at these distances here we will see that the dis-
1643 1207 tance IG is very much greater than the distance IC, and each one is a measure of the pressure of an individual substance. That tells us that the number of molecules of heptane that we have per unit volume of the vapor is much greater than the number of molecules of octane. We have put in twice as many molecules of heptane as we did of octane, but this distance IG is much more than two-thirds of the total distance GC.

If we would measure them off and divide IG by the distance CG we would find that IG was about 82/100, 82 per cent of the whole distance CG.

That tells us that in this vapor over this liquid about 82/100 of the molecules, 82 molecules out of a hundred, are heptane, and only 18 octane.

1644 Now, those present in the liquid, that were put in there, were 66⅔ per cent heptane to 33⅓ per cent octane, or two molecules of heptane to one molecule of octane.

You see when it undergoes the process of changing from the liquid to the gaseous state and undergoes vaporization in there we have had a very considerable increase in the number of molecules of the more volatile constituent, the heptane, over the octane.

What that means, practically, is this: If we take a

mixture of octane and heptane and distill off half of it, cause half of it to vaporize and pass on over and condense, that we would in that process drive off into our vapor, change from the liquid into the vapor, relatively more of the volatile constituent.

In the case of octane and heptane if we would
1644 1208 distill off we would have more than half of our
1645 heptane in the distillate and more than half of the octane running back in the flash. If we would repeat that process we could make quite an effective separation and get practically all of our octane in the less volatile form and practically all of our heptane in the more volatile form.

It would take a lot of fractionation, distillation, to do that, but they have devices, bubble towers, in which they can carry out that process to a high degree of efficiency.

The partial separation of two substances by fractional distillation is illustrated on the chart, Defendant's Exhibit 647.

This is a very simple apparatus made up from
1646 flasks and sealed together. Here in the flask D we have in one case—we have two of these pieces of apparatus but they are just alike so one drawing will do for it—we have in the flask D in the one case a mixture of bromine and carbon tetrachloride.

The flask C at the beginning of our experiment would be empty. It would serve as a condenser.

Now, we chose bromine and carbon tetrachloride because carbon tetrachloride is colorless and bromine has this reddish brown color. There are very few substances that in the vapor state have colors. Bromine is a pretty volatile liquid. It boils at 59 degrees Centigrade. That is 138.2 Fahrenheit.

Carbon tetrachloride is a volatile liquid but less volatile. It boils at 168 degrees Fahrenheit. There is a difference of 30.6 degrees Fahrenheit in the two boiling points, in favor of the bromine. That means that the bromine is much more volatile
1646 1209 than the carbon tetrachloride.

1647 Now, let us put the flask C into a beaker with some ice water around it to keep it cool, apply a flame to the contents of the flask D, and that flask will show the color of bromine, not as strongly as pure bromine because the carbon tetrachloride is colorless and that

weakens the color, but it shows it is bromine. Apply the flame to this and it will rather quickly raise the temperature of the flask to a point where the mixture of bromine and carbon tetrachloride begins to boil. The liquid develops a vapor pressure equal to the external pressure in the flask. When it begins to boil we will have the process of transformation of the liquid into the vapor taking place in there. We will have vaporization occurring with the absorption of considerable heat from this burner.

That vapor will pass up through the liquid, just as it does in water, and it will pass on over into the flask C and turn back into liquid there, removing this heat of vaporization from the vapors in their condensation to liquid.

Now, you might expect from this very considerable difference in boiling point here that the bromine would come over first and then after it all got over that the carbon tetrachloride would come over. If it did that we could see it very easily because the bromine being colored would come on and leave the colorless carbon tetrachloride behind. What happens is that the bromine does come over and come over in increased quantity as shown by the fact that the first drops of liquid that collect in flask C are more highly colored
1647 1210 than the liquid in the flask D. The liquid in flask D would gradually decrease in color as the bromine boils out, but up to almost if not quite the last drop of liquid in there there will still be very easily perceptible color, showing this fact that you can readily enough make a partial separation of the constituents of a liquid by this process of distillation but that it is not a sharp, clean-cut process.

Now, we have the same setup only with iodine and carbon tetrachloride. The iodine is a grayish solid and dissolves in carbon tetrachloride to a beautiful violet color. The vapor of iodine is also a beautiful violet color.

1649 Now, the boiling point of iodine, the normal boiling point, is 363.2 degrees Fahrenheit, way up above the boiling point of water. The boiling point of the carbon tetrachloride is 168.8 degrees Fahrenheit. There is a difference of 194.4 degrees Fahrenheit between them.

It would look as though it ought to be very easy to

separate carbon tetrachloride and iodine. Well, now, when you do that instead of colorless carbon tetrachloride coming over—you see the carbon tetrachloride is the more volatile thing—instead of colorless carbon tetrachloride coming over, the very first drop that condenses in there would be very perceptibly violet in color, showing that the iodine begins to volatilize at once.

As we boil it the liquid in the flask D becomes more and more highly colored. The carbon tetrachloride lingers until the end.

1650 We have here in each of these cases the first step; the vaporization of your material, that is the
1650 1211 process of changing the liquid from the liquid into the vapor state. Then we have, as you can follow it with your eye, the rise of these vapors in the form of bubbles up through the liquid. Then they pass up through the space above the liquid over through some sort of a connection shown here with a side arm tube. That is entirely a separate process from this vaporization. They pass up over through that and over into the condenser and there they are turned back into the liquid state in a separate place, and they are turned back into the liquid state by the absorption of the heat of vaporization, that which produced it from the liquid in the first place.

1651 As to whether the word "vaporization" to me sometimes includes the element of separating or liberating the vapors formed in the liquid from the body of liquid so that the vapors are accumulated above and the liquid remains below, the word "vaporization" to me always means the process of transforming a liquid or a solid from the liquid or solid state into the gaseous state, and that is the end of the process of vaporization.

1652 I identify the following textbooks as standard and authentic works:

"The Science of Common Things" by David A. Wells, published in New York in 1863. (p. 194, DX 648).

1653 Physics for College Students, by Henry S. Carhart, University of Michigan. (p. 375, DX 649).

1659 Physics, by Louis Bevier Spinney, published by the Macmillan Company in 1925 (DX 650).

Physics Advanced Course, by George F. Barker of the University of Pennsylvania (DX 651).

1661 1212 Elementary Treatise on Physics Experimental and Applied for the use of Colleges and Schools, translated by E. Atkinson, 9th Edition, Revised and Enlarged (DX 652).

1666 Inorganic Chemistry for College Students by James F. Norris, 1921 Edition (DX 658).

1213 *Cross-Examination by Mr. Blenko.*

1667 The process of vaporization as described by most people is a purely physical phenomenon as dis-
1670 tinguished from a chemical change. The number of hydrogen and oxygen atoms in a given quantity of water would be the same if the water were in a gaseous or a liquid form.

The word "vaporization" indicates the reverse of liquefaction. "Liquefaction" and "vaporization" are antonyms.

1671 "Evaporation" is vaporization coupled with the removal of vapor from one place to another.

I have had no practical experience in cracking of hydrocarbon oil. My experience with fractional distillation involved running laboratory distillations of oil in 1894.

1674 When heat is added to water, iodine or bromine, the energy thus imparted enables the particular molecule or molecules to fly away from the parent body. If we consider just one atom of a parent substance, say a liquid, it has a certain internal energy, and that energy is increased by supplying heat to the body. Physicists and chemists generally consider that each of these atoms or molecules throughout the mass is in
1675 constant movement. When we reach that point where the velocity of the atom or molecule, as the case may be, becomes sufficiently high, and it is not so constrained by surrounding atoms or molecules, it flies off, and that is called vaporization. It is, of course, the more rapidly moving molecules that pass off. That leaves the average velocity of those remaining behind lower and tends to drop the temperature, is the interpretation that is put upon the cooling effect of the vaporization.

1214 "Q. But this particular molecule whose course we have been examining has flown away from the body, hasn't it?

"A. Yes.

"Q. It has separated from that body?

"A. It has changed from the liquid into the 1676 gaseous state.

"Q. And has separated from the body, has it not?

"A. Yes, distinct from it."

The only useful practical industrial processes which 1677 come to my mind, involving vaporization where there 1680. is no separation of the gaseous substance from the parent liquid body, are baking bread and in soft drinks.

1686 In all my discussions of vapor pressure, and the like, pure substances were dealt with except in the heptane-octane mixture case.

DX 641: The heating of the water in the beaker D to the boiling point would cause a change of state of 1687 some of the water in bulb C from liquid to gaseous form. There would be no ebullition of bubbles. There would simply be a flying off of the molecules of water from the surface of the parent body of water. In that case vaporization would take place from the surface of the liquid.

1688 The "ideal gas law" is one that describes the change in volume of a fixed mass of a given gas with a change in temperature and pressure. In the 1215 discussion previously given I assumed that the ideal gas laws would determine the behavior of the substances. These laws of ideal gases do not 1690 apply to hydrocarbons under pressure of a hundred pounds. As the pressure goes up, the law of ideal 1691 gases as applied to these hydrocarbons breaks down. It fails to apply. Specifically it is inapplicable when you get up above pressures in the range of 100 pounds.

The law of ideal gasses would apply to the more volatile fractions of petroleum at temperatures of 700 to 900° F. and atmospheric pressure.

1691 The latent heat required to convert one pound of water into a pound of steam of 212° F. is 970.4 B.t.u. 1692 per pound. The latent heat of vaporization for gasoline is only a small fraction of that for water.

With rising temperature the latent heat of vaporization of any given substance decreases until the "critical temperature" is reached, at which temperature no latent heat is required to convert liquid to vapor. At the critical temperature every difference of every kind between the liquid and the vapor disappears.

Gasoline is composed of a large number of pure substances. DX 642 is a vapor pressure curve for water. Gasoline, consisting of a number of pure compounds, would have to have a large number of these curves. Water is a typical liquid and the vapor pressure curve, even for a mixture such as gasoline, would have that same general shape. It would be concave upward.

The diagram shown in DX 646 is not applicable to a complex mixture of hydrocarbons at pressures of 100 pounds or over. Petroleum hydrocarbons contain a mixture of different classes of compounds. Therefore, one would expect deviation from Raoult's Law.

I am the author of the article entitled "Beginnings of the Helium Industry", printed in the publication "Industrial and Engineering Chemistry" for August, 1938, the following of which is an excerpt:

"In connection with the separation of gases by liquefaction under pressure, I should like to call attention to the fact that the results often deviate widely from what would be expected from Dalton's Law of Partial Pressures."

"Q. And I note that you spoke of separation of gases by liquefaction under pressure. Did you use the word 'liquefaction' there to indicate a separation of one substance from another?

"A. That is separation in that—I mean for example this extraction of a thing like carbon dioxide from a mixture of carbon dioxide and nitrogen. Separation is getting a thing in one vessel and the other stuff in another vessel, but in doing that we often make use of the process of liquefaction."

I am the author of the book entitled "Inorganic Chemistry", published in 1912, in which the following appears:

"In some cases it is not possible to heat the object to drive off the water and in this case it must be

placed in a closed vessel called a desiccator which contains one of the drying agents already mentioned. Under these conditions the water will vaporize from the object and slowly diffuse to the desiccating substance."

"Q. What do you mean by the word 'vaporize from the object'?

"A. Exactly what it says, change from the condition of water on the surface of the object to the vapor."

1217 "The Principles of Chemical Engineering", by Walker, Lewis and McAdams is used as a reference textbook in the chemical engineering de-
1701 partment of the University of Kansas.

In a simple distillation process, the volatile hydrocarbons are first vaporized and then pass away from the parent body, leaving behind a residue after the vapors have separated themselves from the parent body of the liquid. If a drawoff were provided for
1703 the removal of the residue, and it were used, the residue would be removed from the vessel after the vapors had separated themselves from the liquid oil. If this removal of the residue, in the manner just stated, were to be described as "removing the residue after vaporization", the removal of the residue would have no influence upon the meaning of the word "vaporization" to me. The picture that I would get was that this process of vaporization, the conversion of the liquid into gaseous form, had taken place and then later after the removal of the gaseous product from the liquid in which the vapors were formed, that unvolatilized products had been taken out through
1704 this valve.

1218 *Redirect Examination by Mr. von Holst.*

1705 Referring to DX 641, there is no difference in the vaporization that occurs in the tube C to the vaporization that occurs in the bubbles that are shown diagrammatically in the beaker D.

We have in each case a liquid surface, water in each case, and next to it a layer of gaseous water and at this surface separating the two forms we have the conversion of the liquid water into gaseous water, the vaporization of the liquid part. In each case we have

a kind of a bubble there, in one case the whole of it is formed by the water surface around it, and in the other case part of it is water and the other part of it is gas.

1706 So far as the molecular flying off that I have described on cross-examination, that is as present from the liquid surface of the bubbles as it is from the liquid surface in the glass tube C.

In simple distillation, as you distill off the lighter components of a petroleum mixture, the character of the liquid that remains behind changes in composition as I pointed out yesterday in connection with the octane heptane mixture. That is, it occurs when the vapor bubbles form in the liquid.

1219 FORNEY G. HOOKER, McPherson, Kansas:

Direct Examination by Mr. Theiss.

2513 I am employed by the Globe Oil & Refining Company as stillman. I have been employed by that Company almost four years.

My first contact with the oil business was about May, 1922, with the Empire Gasoline Distilling Company at Arkansas City. There I fired boilers. I was
2514 next employed by the Roxana Petroleum Company, Arkansas City. At that plant, I started in as gauger, and gradually advanced; gauger to pressureman; from pressureman to fireman; and from fireman to stillman.

My duties as fireman were to operate the Dubbs unit under the supervision of the stillman. As stillman I operated one of the units and supervised the fireman in operating his unit. As near as I can give
2515 you, about 1926, I became fireman and directly afterward a stillman. I worked for them until December, 1930. Not all of the time at Arkansas City. I left Arkansas City in 1925, along the first part of the year to go to the Shell plant at East Chicago as stillman. That is the same company.

When I entered the employ of the Roxana Petroleum Corporation at Arkansas City, they had six Dubbs units.

2516 These stills were cracking stills, most of the time

running on topped crude. The oil was fed in at that time with a split feed and governed by the operator, part of it going to the dephlegmator and part in the combined feed of the inlet to the furnace. It would go through the tubes and be preheated and re-
2517 1220 leased into the reaction chambers, the vapors going off to the dephlegmator and the heavier part or coke, carbon, settling out into the reaction chamber. The residue was drawn off at the bottom. These vapors that went to the dephlegmator, the lighter vapors coming off through a vapor line through a condenser coil into a receiver drum; the heavier vapor returning back down the reflux leg and going back into the inlet of the furnace. The pressure was maintained throughout the system.

During the first part of the time that I was associated with these stills, they were operated in the manner that I have just described, that is, on residuum runs.

2518 These stills were on a definite schedule after a fashion. They tried to keep them on sort of a schedule so the clean-out crew wouldn't be bawled up with three or four at one time. On these residuum runs, the schedule, as I remember, was four to five days on stream. In the operation of these stills as a fireman or stillman, while the plant was operating, I watched our tubes and the temperature on the oil coming out of the tubes. We were required to inspect the tubes each hour and make a notation on the operating report as to the condition of the tubes, whether they
2519 were hot or showing any weak points.

In these operations we got hot tubes during the operation. When we got hot tubes, if they were not too bad, we would go ahead and run right through, or try to. If they were bad and looked dangerous, sometimes we would cut the temperature down and go on through. Sometimes we would shut down.

2519 1221 At the end of the operation of these schedules, there was coke found in the tubes, the lines interconnecting the tubes and the reaction chamber, in the reaction chamber, the line from the reaction chamber to the dephlegmator; and there was coke in the dephlegmator on the pans or trays. And we would get coke out of the bottom of the reflux leg, fine
2520 slushy coke. The coke was removed from the tubes

and the interconnecting lines with air motors with cutter heads on them. In the reaction chamber the coke was removed by pulling a cable out of the bottom. In the dephlegmator we would remove the top head, pull the pans up with a chain hoist, and go down in there and clean it out. Usually push what was in there in the dephlegmator bottom, push it down over the leg and let it drop out the bottom. The pans would be scraped off and cleaned up, blown off with steam and put back. Then on the leg at the bottom, they removed the blind on the bottom of the reflux leg. All lines were inspected each time to see that
2521 we removed all the coke.
2522 We tried to burn the residuum from these operations on our stills and furnaces. Had considerable trouble with it for it contained a good bit of coke, had trouble with it coking up our burners and valves and lines leading to them. Stored it in tanks and tried to let it settle, and then burned it, made it a little better but we still had a good bit of trouble with it. They would clean the tanks out occasionally.

After about a year, we went to a different type of operation, known as non-residuum operation.
2522 1222 That is practically the same operation as the other only you do not draw any residue from the reaction chamber. We went to the non-residuum operation to get away from the residuum.
2523 The schedule of operation, to the best of my recollection, on the residuum runs on these Dubbs stills was five or six days. The charge on these residuum runs was topped crude from the topping plants.

On the non-residuum runs we cut the operating schedule down to about two days on-stream. The carbon was distributed in the apparatus at the close of the run in these non-residuum runs the same as on
2524 the other runs. It formed a little faster in the reaction chamber. The carbon was cleaned in the same manner as I have described before.

In the operation of these Dubbs stills at Arkansas City, we had a pump in the line interconnecting the dephlegmator and the tubes. They installed the first pump, in 1925. Later on, installed pumps on the rest of the units. The first pump that was installed was an upright centrifugal pump driven with an electric motor, a Byron-Jackson pump. Later they installed

the same type of pump only driven with a steam turbine. Later on they changed these to a Dow re-
2525 ciprocating pump. When these first pumps were installed and put into operation, the pump was inspected or cleaned; not every run but it was inspected occasionally. Usually the head was taken off after a few runs and inspected. Usually cleaned out the coke which formed in there, at times hard carbon would form in the head of the centrifugal pump, around the impeller. Later on, they installed a Dow
2525 1223 reciprocating pump. These pumps were put in place of the centrifugal pump, not because the centrifugal pumps were worn out but because the Dow pumps were more satisfactory, did not give as much
2526 trouble. We did not have so much trouble with carbon forming in the Dow. There would be hard carbon form in the pots that the valves were in. They did not have to clean them out a good deal but occasionally had to repair the valves, usually at that time they would burn this carbon out with an acetylene torch.

After we started running these stills non-residuum, the stills were not run on the old residuum basis very much. I think they ran once in a while, we always burned fuel oil so they used to run it enough to furnish our fuel oil.

As to how we handled that fuel oil, we did considerable experimenting with our storage tanks, trying to find some way of settling out this carbon, tried to filter it at one time which did not work, and finally hit on the plan of pumping it into the tank from the still and leaving it there three or four days and then burning it. By changing our burners occasionally
2527 and cleaning them, we were able to burn the residue after a fashion.

These stills at Arkansas City were running on this residuum run when I was transferred to East Chicago. In East Chicago, it was practically all non-residuum runs. They did make a few residuum runs because we burned residuum there. They had six Dubbs stills when I first went there. They were larger than at Arkansas City, more tubes, double reaction
2527 1224 chambers, 10 x 40. Larger throughout.
2528 At East Chicago, the cycle was 56 hours on-stream on the non-residuum operation. 12 to 15 days

was their cycle on the residuum runs in these larger plants. The carbon was distributed throughout the system at the end of the run on these stills at East Chicago practically the same as that in the original unit at Arkansas City throughout. They were cleaned out in the same way. In the dephlegmator of these stills at East Chicago, they installed an extension known as a coke trap on top of the reflux leg inside of the dephlegmator and extending up about
2529 18 inches; had a cap over that with saw teeth under it so the oil could go up and down through into the leg. We occasionally had some large chunks of coke that came down and got into the pump. We installed this to catch those chunks of coke that might form and go down. The installation of this extension helped in that respect.

1225 *Cross-Examination by Mr. Hall.*

2529 For the past six weeks, I worked at the Globe Oil Company at McPherson on their big still and also on the vapor phase experimental operation for the Winkler-Koch Patent Company. Herman Dunn was
2530 my superior. Dr. Rittman appeared to have charge
2531 of the work. At this experimental plant, there were some Universal men and some Cities Service men. In addition, the other operators were Henry Ede, Jim
2532 Fosha and Hall McManus and one man was from the National Refining Company. I assume that Dr. Rittman worked for the Winkler-Koch Patent Company. I was paid by checks that had the Winkler-Koch Patent Company's name on them.

I first went to work for the Shell Company at Arkansas City during the first part of 1924 as a pres-
2533 sure man and fireman. Sometime in 1925 I became a stillman. The Arkansas City plant had six standard five hundred barrel Dubbs units. Later Nos. 7 and 8
2534 Dubbs units were installed, these being somewhat larger than the standard five hundred barrel units with two ten by forty feet reaction chambers. The effect of the second reaction chamber would be to increase the length of the run.

I worked on the Dubbs units at Arkansas City in
2535 December, 1925. The No. 2 Dubbs unit was then running with a hot oil pump and double chamber. At

about that time, the No. 2 unit, with gas oil as the charge, ran thirty-six days. I do not know whether they produced a yield of forty-six percent gasoline but I remember working on the thirty-six day run.

2536 The pressure was about two hundred pounds.

2537 1226 From my experience at Arkansas City, the following data sound reasonable: A run was made on a Dubbs unit in December, 1925 at the Shell Company in Arkansas City which was 881 hours on stream with forty-eight percent yield on the charge of Navy Gasoline, the charge being gas oil, the oil transfer temperature being 880° F. and the pressure being about two hundred pounds.

2539 I was employed by the Shell Company at Arkansas City during the middle of 1924 and continued there

2540 until December 1, 1930 during which time I worked on Dubbs Units known as Nos. 1, 2, 3, 4, 5, and 6. I do

2541-2545 not remember the yields or the character of the residuum. The residuum from the thirty-six day run would be as suitable as the residuum from the other runs as fuel oil. I do not recall any cleaning of the dephlegmator after the making of gas oil runs.

2546 The Shell Company ran residuum runs on the Dubbs units to obtain residuum which they burned as fuel. Coke which was made in these runs was shipped out and, I presume, sold.

2548 Most of the runs about which I testified on direct examination used topped crude as a charging stock. I do not remember the gravity nor do I know much about how the topping operations were conducted.

2549 Some of the Dubbs units at Arkansas City had re-

2550 action chambers added sometime in 1925. The still originally was equipped with a small reaction chamber for which a ten by thirty chamber was substituted and, at a later date, a second ten by thirty

2551 chamber was added. After the change, the on stream time would have been five to six days with the residuum operation and, with the non-residuum operation, about two days. I do not know anything about yields.

2552 1227 Shut-down of Dubbs Unit: When the Dubbs unit was shut down and opened up, the two reaction chambers were found to be fairly full of carbon and coke. This was true both as to residuum and non-residuum operations.

The steps in shutting down the Dubbs residuum
2553 run are as follows: (1) Gradually cut the fires. (2)
2554 Cut the raw oil feed. (3) Circulate some pressure distillate from the bottom of the dephlegmator through the heating tubes into the reaction cham-
2555 ber and to the dephlegmator. (4) Draw the heavier
2556 oil from the bottom of the reaction chamber continuously during step 3. (5) "Drop out" the oil from the reaction chamber. At a later date, steam
2557 was blown through the tubes into the oil on top of the reaction chamber and from there to the dropping-
2558 out line to the pit. Some of the steam might get
2559- into the dephlegmator when steaming out for two
2561 or three hours. (6) Introduce water into the reaction chamber for about two hours. (7) Clean out
2562 the still; turbine the tubes, transfer lines and connecting line to the dephlegmator; and remove coke from chamber.

2563 The non-residuum and residuum clean-outs were practically the same.

2565 A little steam during the steam period on the shut-down of the Dubbs unit might have passed from the reaction chamber to the dephlegmator and then down through the dephlegmator.

All the testimony given in my direct examination is from recollection.

2566 I discussed these runs with Ede and Kerting.

1228 FORNEY G. HOOKER, McPherson, Kansas:

Redirect Examination.

2566 Gas oil was not used very much as charging stock in the runs that I was associated with on these Dubbs stills at Arkansas City and at East Chicago.

Recross Examination.

2567 I do not remember the number of runs which were made on Dubbs unit No. 2 in which gas oil was used as a charge.

1229 HENRY M. EDE, 818 South Main, McPherson, Kansas:

Direct Examination by Mr. Von Holst.

2413 I am still operator at the Globe Oil & Refining Company, at McPherson, Kansas, and have been engaged in that capacity since March, 1933. I first started to work in the oil industry in March, 1922, 2414 at the Roxanna Petroleum Corporation, located at Wood River, or Roxanna, Illinois. In June, 1922, I went to work on the Dubbs No. 1-A unit at Roxanna as a pressure man. Universal Products Company was supervising the operation of this plant at that 2415 time. This operation was experimental.

The apparatus of this No. 1-A was a box type furnace, convection heat, and had 32 tubes. The heat was fired from one side of the box against the fire wall, and the suction in the stack pulled the 2416 heat down through the tube bank in back of the bridge wall.

The oil entered at the bottom of the bank as one continuous coil and discharged out the top part of this tube section through a transfer line into a horizontal reaction chamber. In this reaction chamber the liquid level was held and the residue was continuously drawn through a residue draw-off line, and the vapors from the reaction chamber passed through the vapor line to a dephlegmator, the lighter ends were passed from the top of this dephlegmator through a vapor line, through a condenser box into a P. D. receiver, and at the bottom of this aforementioned dephlegmator was a leg extending down toward the tube entrance. On this particular operation the fresh feed was charged directly to the 2416 1230 tubes, and the recycle came down this dephlegmator leg and united with the fresh feed to the tubes, what they call a combined feed.

2417 The pressure was maintained throughout the system up to the P. D. receiver.

While this plant was being operated by the Universal Oil Products Company there were a number of runs made. The coke deposit at the end of the runs varied. They found coke at the top layer tubes,

and they had trouble with coke in the transfer line, and there would be some coke in the reaction chamber. And when they removed this flange on the trap on the dephlegmator leg there would be some fine slushy coke in it.

When the plant shut down I helped clean it. I saw the coke in the various parts of this apparatus.

The first few runs were made on gas oil charge 34-36. To remove the coke, the tubes were turbined with an air driven motor turbine, and the transfer line and the tubes to the reaction chamber were turbined. The manheads on the horizontal reaction chamber were removed and the coke was pushed towards these bottom manheads with bars, and from these bottom manheads it would drop to the base underneath and be hauled away in a wheelbarrow. The vapor line from the reaction chamber to the dephlegmator was always inspected and at times turbined with a large motor turbine, then the flange was removed from the bottom of the dephlegmator leg, and a barrel would be placed underneath to catch the oil and loose coke and asphalt that was released when the flange was removed.

1231 On the gas oil runs the tubes in the furnace were in fair shape; some coke in the transfer line; we would have trouble with coke in the transfer line. In one particular case, to the best of my recollection, there was about a half inch wall thickness of carbon in the transfer line.

Just before Roxanna took this plant over, Universal made a run, using topped crude for a charge. On this run, the coke throughout the system in the same parts mentioned was greater, especially in some of the tubes.

In the top row of tubes there was a great amount of carbon. The transfer line had a great amount of carbon. More carbon in the reaction chamber, and the vapor line to the dephlegmator would have more coke, and more coke would be removed from the flange on the dephlegmator leg.

While this No. 1-A unit was being operated, Dubbs Unit No. 2 was being constructed by Universal at the Roxanna plant. The operation of this No. 2 unit was started around the latter part of 1922. The

first few test runs on this No. 2 unit were made under the supervision of Universal and were experimental. They were experimenting with all fresh feed to the dephlegmator. They had considerable trouble with
2422 puking where the heavy oil would carry over into the P. D., and when the temperatures were lowered to avoid this puking the P. D. percentage would be too low.

It was found that only a percentage of the fresh feed could be cut to the dephlegmator, and the balance charged direct to the tubes, to the furnace. This method of feeding when some was fed
2422 1232 to the dephlegmator and the other directly to the tubes was called split feed.

2423 The No. 2 unit to the best of my recollection, had 34 tubes and had two vertical 10 by 10 reaction chambers, hooked in parallel; otherwise the plant was more or less similar to No. 1-A.

During the time that the Universal Oil Products Company was operating this No. 2 plant, the only part that I played was that I would fire the unit. After Roxanna took over No. 1-A, I was fireman on No. 1-A and adjusted the fires on No. 2 on order.
2424 Later on when No. 2 was taken over by Roxanna I ran No. 1-A and the stillman ran No. 2 and supervised the operation on No. 1-A, and if one unit was down for a cleanout, the other unit operating, it was my duty to run the plant that was in operation.

When I was employed in the operation of the No. 2 unit, the operation was mainly on topped crude charge with a split feed. The range of temperature
2425 on the transfer line was somewhere between 875 to 900. The two chambers eventually were both put in use, and one transfer line discharged into both chambers. We had six try-lines along the different heights of the chamber, and by opening these valves and looking into the oil around the try-lines you could determine where the liquid level was in the reaction chamber. The oil level was maintained in the reaction chamber by releasing the residue from the draw-off valve.

2426 At that time, they usually started out with the oil in the fourth try-line from the bottom and vapors in the fifth.

2426 1233 The pressure was maintained on No. 2 similar to No. 1-A. The pressures ranged from 110 to 160 receiver, depending on the charge.

At the time when units No. 1-A and 2 were taken over by the Roxana, no definite operating schedule had been worked out. The shut down of the runs on these units was caused by the chamber filling with
2427 coke. At the end of a run, the carbon on No. 2 was deposited similar to No. 1-A; in the tubes, transfer line leading from the tubes to the reaction chamber, in the reaction chamber, the vapor line to the dephlegmator, and the flange, after which the flange on the bottom of the dephlegmator leg was removed and the coke released from this dephlegmator leg.

The carbon was removed from these vertical reaction chambers at first by a chain, but they had considerable trouble with chains. They finally found that a cable was much more efficient so a cable was installed. Hooks were welded on the walls of the reaction chamber. Before starting a run, the chain was tied to these hooks, wound around throughout the reaction chamber, the idea being to pull this chain and break up the coke so it would fall out at
2428 the bottom. At the end of the run, the chain was removed by a steam hoist.

During these operations the dephlegmator was not cleaned until we had trouble with pukes on the regular run. Then when the plant went down for cleaning out, the dephlegmator would be cleaned.

2429 During the time that I was operating these units No. 1-A and No. 2, Units 3 to 8 were being built
2429 1234 by the Universal Oil Products Company at this plant.

Units 3 to 8 had a larger capacity, more tubes, 50 tubes; the dephlegmator was higher and the capacity was greater. It was considered a 1000-barrel unit.

2430 Units 3 to 8 were ready to operate during the year 1924.

2431 After a shut down of the cracking department in 1923 they started up Dubbs units No. 1-A and 2 and 3 and 4 in December, 1923.

I was acting stillman on Dubbs No. 1-A and 2, and was promoted to stillman the first of January, 1924.
2432 These Dubbs units operated on residuum runs at the

time when I was stillman. The residue was drawn from the reaction chamber. To get the proper gasoline yield in these operations, the residue would contain a high B. S. content. To overcome this difficulty with the high B. S. content in the residuum and to keep this B. S. per cent 1% or lower, the temperature of the furnace and the transfer line would be lowered. That transfer line temperature ranged between 800
2433 and 825. The P. D. yields were 20%, around 20% P. D. In all of these operations the end point of the gasoline which we were working for was 437 degrees F.

The type of operation making this residuum with 1% B. S. was continued and then stopped due to the accumulation of Dubbs residuum and the low
2434 recovery of pressure distillate. They ran that way until the accumulation of residue became a problem.

Later on, to overcome this B. S. content in the residuum, experiments on Dubbs 7 and Dubbs
2434 1235 No. 2 were made on the non-residuum or coke run. The residue was left in the reaction chamber and not drawn off, and an effort was made to boil everything in the reaction chamber down to
2435 coke. I assisted in these non-residuum operations.

There was a greater yield of gasoline per barrel in the non-residuum operations as compared with the residuum operation.

2436 The carbon deposited at the end of one of these non-residuum runs was similar to the residuum run except there was a greater amount in the tube and a greater amount of coke in the vapor line from the reaction chamber to the dephlegmator, and more slushy coke would be removed from the dephlegmator leg. These non-residuum runs were not continued after these experiments had been conducted on these stills at that time. These two particular units were put back on the residuum runs.

2437 On non-residue runs, the height of the coke level in the reaction chamber would be according to the length of run, and the formation of the coke was similar to the residue run. As to the length of these non-residuum runs that were conducted during these experiments on No. 7 they considered 48 hours a good run, where on No. 2, with the two reaction chambers,

they ran as high as four days. Some time prior to 1926, single stake Byron-Jackson centrifugal hot oil pumps were installed on units 3 to 8 and 1-A and 2, at the Roxana plant to increase the velocity of the oil through the heating tubes. These hot oil pumps took suction from the dephlegmator leg through a line that
2438 came off a T. The hot oil pumps had a tendency to increase the throughput slightly.
2438 1236 After these Dubbs units Nos. 3 to 8, Dubbs units 9 to 12 were installed at the plant the latter part of 1926. These units differed from units 1 to 8 in that they had 62 tubes and a 10 by 40 reaction chamber and a two stage Byron-Jackson centrifugal hot oil pump. I was transferred to 9 to 12 to help start these units. The first runs were residuum runs. The charging stock was mainly topped crude.
2439 These units were placed on four days on stream or five day cycles, six and seven day cycles. This was a regular operating cycle at that time for these units. The carbon deposited on these units was similar to the carbon deposited on 1-A to 8.

After a few runs were made on 9 to 12, larger chambers, 10 by 30 chambers were installed on the units 3 to 8, and the Byron-Jackson hot oil pumps were being replaced with Dow hot oil pumps.

After the units 9 to 12, additional Dubbs units, 13 to 16, were installed at this plant, about 1927. These
2440 units were the same as units 9 to 12. They were operated on residuum and non-residuum runs. The operation was about the same as 9 to 12. After all of these Dubbs units had been installed, they made mostly non-residue runs, and just enough units were run on residuum runs to supply the refinery with fuel. This residuum that was made for fuel oil in the plant on these Dubbs runs had high B.S. content. There was considerable difficulty in firing with this
2441 residue, and so they had three run-down tanks hooked in series. The oil was run down or discharged
2441 1237 into the first tank and equalized between the other three tanks, and then the fuel charge was pulled out of the fourth tank. The B.S. would settle out in the first tank, and when this coke level was built up this tank could be cut out and cleaned to remove the coke.

2442 In about 1927 when these Dubbs stills were all in operation, the run that seemed to be the most popular at Wood River in running these stills non-residuum, was the four day cycle, three days on stream and some three day cycles were made. The charging stock used was topped crude mostly.

I was employed on these stills in 1927 as stillman. In October, 1929, I was made assistant still foreman.
2443 I left the employ of the Shell the first of January, 1931.

In these Dubbs units at the time that I operated those units at Roxana, they extended the dephlegmator leg into the dephlegmator about 18 inches, carried a standpipe. This was to allow the coke to accumulate in the bottom of the dephlegmator which could be removed when the dephlegmator was cleaned and would not be carried into the hot oil pump to cause any difficulty with the pump. I can't recall the date when this extension was put into these dephlegmators but they had trouble with coke in the impellers of these Byron-Jackson pumps; and also they had trouble with the pumps in that they would lose suction, and they always found coke in the dephlegmator leg, so these standpipes were installed and the pumps
2444 operated smoother. On the top of this extension of the dephlegmator leg there was a cone shaped affair or hat attached so the oil would have to work
2444 1238 up underneath it to go down the leg.

In all of these Dubbs operations, to the best of my recollection, the carbon was distributed throughout the system as I have described.

We did clean the dephlegmator on these Dubbs op-
2445 erations. After the plants were placed on a regular operating schedule, every three or four runs the dephlegmator would be cleaned. The head from the top of the dephlegmator was removed, the pans were lifted out, the coke removed, the holes in the dephlegmating pans were punched out to remove the coke that had sealed the holes up, and the coke was removed from the bottom of the dephlegmator where it had piled up due to the standpipe, and after this coke was removed a man held a light down at the bottom of the leg while the operator looked through it to see if the line was absolutely free of coke so there

would be no restriction there to affect the suction head of the hot oil pump.

Instructions were issued to the operators respecting the cleaning of the various parts of the equipment.
2447 There was a clean-out report that we had to keep that described the cleaning of the apparatus and the inspection and repairs. This clean-out report stated
2448 just which part of the apparatus to clean, and O.K.ed after it was cleaned.
2449 In the operation of these Dubbs units as I operated them at Roxana, it was customary to watch the heating tubes in the furnace, to watch for hot spots and any sign of weakness.
2449 1239 We were given written instructions to watch
2450 these tubes. We were advised to avoid vaporization of the oil in the tubes as that caused hot spots. Instructions, both oral and written, were given to us to avoid the hot condition of the tubes when it occurred. When the tubes became hot, we were to immediately get in touch with our supervisor and lower
2451 the temperature; also cut the throughput fresh feed charge. On a non-residue run, the plants were accustomed to go down a certain time, and if you lowered the temperature the level in the reaction chamber fell too fast. To offset that we sacrificed throughput.

1240 *Cross-Examination by Mr. Thomas.*

2451 I am now employed by Globe Oil & Refining Company at McPherson, Kansas, which company operates Winkler-Koch cracking stills. I have operated these stills at McPherson since 1933. In the past few
2452 months, I operated a Hall process at the Globe Oil & Refining Company plant at McPherson, under the direction of Herman Dunn of the Winkler-Koch Company. In this work, I was associated with Bradley, Hooker, Fosha and McManus. Dr. Rittman was in
2453 charge of the work. This was experimental work to prove certain theories. I was first detailed to this work in September of 1936. I was paid by the Winkler-Koch Company for my work on this experi-
2454 mental still.
2455 About a year ago, December 1935, I was called to
2456 Wichita and asked to tell my experiences as a Dubbs

operator to Mr. Thiess. Since that time, I have talked about my experience with the Dubbs operation at the Shell plant with Mr. Hooker and Mr. Kerting. Hooker is the stillman of the Globe plant at McPherson. Kerting formerly worked at Arkansas City for the Shell.

2457 I heard that the Globe Oil Company was a defendant in a suit instituted by the Universal Oil Products Company.

Dubbs Units at Roxana: All the testimony I gave today regarding Dubbs plant at Roxana was from memory, without refreshing my recollection. I left the Roxana plant in January of 1931 and have never been back since.

2458 Roxana No. 1-A Unit was not an experimental unit, but the work was an experimental operation. It was started up in June of 1922 by representatives of Universal Oil Products Company and operated by them until the first of September of that year, 1241 when it was turned over to the Shell company. After that it was operated as a regular commercial unit.

2459 This unit operated from 1922 until about 1930. The normal transfer temperature when using a topped crude charge ranged from 890 to 900°F. With a gas oil charge, the transfer temperature was 850 to 2460 875°F. Transfer temperatures of 900°F. were used in 1922. Forty-two percent gasoline was 2461 produced from topped crude charging stock. This yield was sometimes exceeded. The unit always ran 2462 as a residuum operation. It ran 5 to 10 days on 2463 stream with the gas oil charging stock. The gasoline 2464 yield was somewhere between 33 and 40 percent.

Other Dubbs units produced as high as 55 to 60 percent gasoline from Mid-Continent topped crude on a non-residuum type operation.

"Puking" sometimes occurred in the stills. Puking is the carrying over of the recycle or part of the charge with the pressure distillate, thus making very poor quality pressure distillate. This occurred due to a dirty dephlegmator and sometimes when there was no hot oil pump, it was due to insufficient pressure to force it through the tube bank. Also, it might have been due to trying to feed too much charge.

2465 Dubbs Unit No. 2 at Roxana: Mr. Huff and Mr. Seguy of Universal had charge of the test runs, after which the plant was turned over to the Shell Company. The Dubbs unit was running both residuum and non-residuum type operations and used some gas
2466 oil but mostly topped crude as charging stocks. Some
2467 of the runs were of 5 to 12 days duration. There may have been operations as long as 15 days. Yields of 45 to 55 percent gasoline were made with the
1242 non-residuum type of operation using topped crude. Yields of 40 to 45 percent were produced with the residuum type of operation. Topped crude was the charging stock in the residuum operation. Some of the runs were 5 days on stream with two chambers. The pressure ranged from 110 to 140
2468 pounds per square inch and the transfer temperature on topped crude was from 875 to 900°F. In succeeding Dubbs units with hot oil pumps in 1924 and 1925,
2469 temperatures of 900 to 910°F. were used with pressures of 140 to 160 pounds.

2470 Beginning with the No. 3 Dubbs unit at Roxana, the transfer temperatures were 910 to 940°F. and the pressures were 140 to 160 pounds. This was for non-residuum type operation, with a charging stock of topped crude comprising a mixture of Mid-Continent and West Texas topped crude. These operating conditions began sometime in 1925 to 1927 when hot oil pumps and larger chambers were installed. From 1927 to 1930 all units ran non-residuum with the exception of those running residuum to supply fuel for the plant.

2471 Dubbs Units 1-A to 8 operated from 1924 or 1925 and produced a residuum which had less than 1 per-
2472 cent "B.S." (Bottom Sediment.) This type of operation lasted from one month to not more than six months, during which time less than 20% gasoline
2473 was produced. The pressure during this period of operation was 160 pounds and the transfer temperature was 800 to 825°.

2474 Because of trouble in burning Dubbs residue, we discharged residuum into three tanks wherein some of the sediment contained in the residuum settled. After this settling, residuum could be burned as a

fuel oil. The residuum in the tanks had about
2475 1243 10 per cent B.S. Therefore, 90 percent of the oil was suitable for fuel oil if the B.S. could be separated.

On Unit No. 1-A, there seemed to be more trouble with coke in the transfer line from the heating tubes to the chamber than with other units. I recall one run in which there was a deposit of one-half inch of
2476 coke. The minimum deposit of coke on a run using gas oil would be frequently less than one-eighth of an inch. The deposit which I just mentioned, of one-
2477 half of an inch of coke had an unusually heavy one. In runs on other Dubbs units, we frequently found less than one-eighth of an inch of coke deposited in
2478 the transfer line. It would be an unusual occurrence to find a coke deposit of one half of an inch in the transfer line. Before hot oil pumps were installed on units other than 1-A it usually averaged one-fourth inch thickness.

Dubbs Units 3 to 8, when running on the non-residuum type of operation, had a four-day cycle, three days on stream and one day for cleaning. The reaction chamber was 10 by 30 feet. When Dubbs Units 9 to 12 were installed, 10′ by 40′ reaction cham-
2479 bers were used. The result of this was a greater throughput and the production of more pressure distillate in the same length of time. With the Dubbs Units 9 to 12, the cycle was five, six and seven days for residuum operation. On non-residuum operations, they ran three and four-day cycles.

2480 Dubbs Units 3 to 8 were first built with 10′ by 10′ reaction chambers. Later, a larger reaction chamber and a hot oil pump were installed, the effect of which was to treat more oil per cycle with the larger chamber than with the small chamber, because of the larger coke capacity of the chambers. In the normal
2480 1244 operation of these Dubbs stills, the termination of the run would be brought about by the substantial filling of the reaction chamber with coke.

2481 Dubbs No. 2 unit, as originally installed, had one reaction chamber. Subsequently a second one
1245 was added. In the non-residuum type of operation, the addition of the second reaction chamber increased the throughput and permitted a longer

on stream time. With the residuum type of operation, you could treat more oil in a given period of time.

On a residuum type of operation, coke in the reaction chamber was permitted to build up within two and a half feet from the top. On top of this coke there would be a body of oil. At the end of the run, dark oil was drawn from a point about two feet from the top of the chamber. The run was terminated when the coke level reached a point two and a half feet from the top of the chamber to prevent coking of the vapor line from the reaction chamber to the dephlegmator.

In the non-residum type of operation, a higher coke level was carried, about two feet from the top of the chamber. There would be a layer of oil above the coke.

Procedure in Shutting-Down a Dubbs Unit: The fires were first extinguished. The next hour was consumed in withdrawing liquid residuum from the reaction chamber. Steam was then introduced into the reaction chamber and the tubes for the purpose of forcing the liquid oil out of the still. During this period, the steam was in contact with the coke, tar and oil in the reaction chamber. The dephlegmator was in open communication with the reaction chamber. Water was next introduced into the reaction chamber which was at a temperature of 500 or 600° F. The water vaporized in the reaction chamber. The vapor line to the condenser would be open. The purpose of the operation was to cool the plant and dry out the tar and things of that kind that remained in the reaction zone.

After the coke in the reaction chamber was cooled, it was removed by means of a cable embedded in the coke. The remainder of the coke was knocked off the chamber by means of iron bars. However, there would be a coke layer remaining on the walls after the cleaning. On the 10 x 40 reaction chamber we got as high as 90 cars of coke.

1246

During the time the coke in the chamber was being removed, the heating tubes as well as the vapor line from the reaction chamber to the dephlegmator were turbined. At times, a little coke was found in the

vapor line. The vapor line extending into the chamber was inspected after every run and cleaned, if necessary.

The dephlegmator was cleaned after every three or four runs on non-residuum type of operations and after four to five on residuum type.

2500 The amount of coke in the dephlegmator varied in different runs, even when the still was operated with the same charging stock and under the same
2501 general conditions. On the non-residuum type of operation, there would be found ninety tons of coke in the chamber and two hundred to five hundred pounds of coke in the tubes. The amount of coke in the dephlegmator for these periodic cleanouts would be five hundred to one thousand pounds. The coke in
2502 the chambers for this same period of time varied between two hundred forty to three hundred tons.
2503 In the residuum type of operation, the coke in the dephlegmator for these periodic cleanouts varied from one hundred to one thousand pounds and the coke in the reaction chamber would be about four hundred tons. I cannot account for the wide variation of one hundred to one thousand pounds of coke in the dephlegmator.

2504 Dubbs Stills Nos. 3 to 16 were not originally
1247 equipped with standpipes in the dephlegmators.

The coke in the bottom of the dephlegmator would be less than when the dephlegmators were equipped with standpipes. In the former case, there would be about two hundred pounds of coke adhering to the walls.

2505 Starting Up a Dubbs Unit: After the unit was all cleaned out, it was filled with charging oil and tested
2506 for leaks or weaknesses. The fires were lit and the oil was circulated by withdrawing it out of the dephlegmator through the pump through the heating coil and into the reaction chamber, during which time
2509 the temperature would not exceed 700° F. This circulation continued for about an hour or two.

1248 *Redirect Examination by Mr. Theiss.*

2509 In my cross-examination, I was asked about my conversation with Mr. Thiess at Wichita one afternoon.

I was called down there and I didn't know what it was all about. Mr. Thiess was interviewing several
2510 other people, and he asked me on this Dubbs operation, and I hadn't even given it any thought, and didn't have the time to cover it that day, so I wrote Mr. Thiess the story according to my memory of my experience, and I went down the next day, and a stenographer was called in and I wrote my story and I signed the paper.

In my cross-examination, I stated that we used a 900 degree temperature when we started to feed into the dephlegmator. That is with the hot oil pump. We went to this higher temperature at this time for greater through-put and to pull the gasoline yield up.

The 1-A plant was only run on the residuum runs and never run on non-residuum runs on account of the horizontal chamber. The chamber would not be practicable for non-residuum runs because it didn't
2511 have the coke capacity. The chamber was too small.

I have testified in cross-examination about the use of this residuum for fuel after it had been allowed to settle out. This residuum thus used for fuel was not entirely satisfactory. We had to make special burners and special provisions for it. If we
2511 1249 did not use those special burners and make these special provisions, we experienced difficulty in plugging up the burners.

I was cross-examined at some length about the level of carbon in the reaction chamber, and stated that that was about two feet from the top. When this carbon was allowed to build up higher, it would form too much coke in the vapor line. That sometimes happened. The vapor lines are hard to cool due to
2512 running at high levels. I have seen quite a bit of coke in the vapor lines caused by that condition. When we kept the level at about two feet, the carbon in the vapor lines was less great. Sometimes it would be in good shape. To remove this carbon from the vapor line, we had a special turbine, a large turbine for this purpose only. The turbine was special in that it was an 8-inch vapor line and the turbine was larger in order to fit the line and to clean the side walls absolutely clean.

1250 LON E. BACKUS,* 343 North 13th, Kansas City, Kansas:

Direct Examination by Mr. Theiss.

2294 I was employed by the Universal Oil Products Company on or about February 17, 1919. I then first worked at Independence, Kansas, as stillman's helper on the Dubbs plant No. 2. My duties were to watch the pressure, maintain the oil feed, gauge the run down tanks, and help the stillman with the fires when he needed it. On the cleanouts my work consisted 2295 of cleaning the 4-inch heating coils.

At the time of my employment by Universal at Independence, the No. 2 Dubbs unit was being re- 2296 modeled. I helped in the reconstruction of this plant. The reconstructed plant No. 2 consisted of a series of 4-inch heating coils, 10 in number, connected with the pressure line to a series of three 10-inch reaction chambers, these being connected with a vapor line to a coil aerial condenser; the aerial condenser being connected to a receiver tank through the vapor line coil condenser box. There was a header on the vapor line with a reflux line leading to the intake on the 4-inch heating tubes. These 4-inch and 10-inch tubes were approximately 20 feet long. The 10-inch reac- 2297 tion tubes had three try cocks and a 2-inch connection for drawing off residue.

After the plant had been reconstructed, I assisted in its operation as stillman's helper. During the runs on this plant they were fired and brought on- 2297 1251 stream, and maintained at a given oil feed of from 1½ to 3 gallons per minute, with the pressure maintained from 70 to 100 pounds throughout the apparatus. The plant would run approximately six days and would be shut down for cleanout. Dur- 2298 ing the operation of the plant there was a liquid level maintained in the 10-inch reaction chamber which was approximately half full; this being done through the residuum drawoff line with a control valve.

At the end of the run the plant would be opened

* Deposition given December 10, 1936.

up, and we found the 10-inch reaction chambers full of carbon; the 4-inch heating coils would have an excessive amount of carbon in them; and the reflux line leading to the intake of the 4-inch heating coil would have carbon and mushy carbon. Some of the 4-inch coils would have carbon possibly one-eighth of an
2299 inch thick; very hard. The amount of carbon in the coils would vary according to the charging stock that was run and the length of the run. Sometimes it was more than that. The greatest amount of carbon that I remember of seeing in these heating coils was approximately in place a half inch thick. The 4-inch tubes were called the cracking tubes. The 10-inch being called reaction chamber.

I have some recollection of a run which was made for representatives of the National Petroleum Association some time in the summer of 1919. I was present and assisted in that run as assistant operator.
2300 The length of that run was approximately six days. At the end of this run the 4-inch cracking tubes had considerable carbon; the 10-inch reaction chambers were full of carbon; the reflux line leading to the intake of the cracking tubes had mushy carbon and carbon.

2300 1252 In these runs at the No. 2 plant at Independence that I assisted in, carbon was removed from the 4-inch cracking tubes at the end of the run by a turbine which was forced through the tubes breaking the carbon loose and forcing it out. On the 10-inch reaction chambers, this carbon was removed by long crowbars and hoes for pulling it out. The reflux line as a general rule could be steamed out and
2301 the stuff forced out with steam. In the operation of this No. 2 plant at Independence we had trouble with these 4-inch heating tubes getting hot spots. It was necessary frequently to replace these tubes due to getting too hot, bending and sagging. In the operation of this apparatus, it was a practice to carefully watch the tubes to see if any hot spots developed or if the tubes were getting hot. In these operations I saw these tubes get hot. When we got hot tubes, as a general rule either the furnace temperature was dropped or the raw oil feed increased.

2302 During the time that I worked on this plant No. 2

at Independence, the aerial condenser was raised approximately 20 feet.

I stayed with Universal on this No. 2 plant at Independence about 18 months. During the summer of 1920, I was laid off. I re-entered the Universal's employ about May of 1921 at the Dutch Shell Refinery at Wood River, Illinois, sometimes known as the
2303 Roxana plant. I was employed at this Roxana plant as fireman on the Dubbs cracking plant No. 1 until the final operation on December 5, when the unit exploded.

2304 My understanding is the explosion was due to the hurry in trying to cut down the number of hours
2304 1253 from the shut-down to back on-stream. While the plant had quite an air pressure, raw charging stock was pumped into the plant, causing it to blow up. I was on the operation when this occurred, and was injured.

The No. 1 plant at the Shell Refinery, Roxana, consisted of four coils of 4-inch heating tubes with two banks of 10-inch reaction chambers. Six reaction chambers all told. These were hooked to the bottom of the dephlegmator with vapor line. The top of the dephlegmator was connected to a pipe coil condenser and receiver tank. The bottom of the dephlegmator
2305 had a reflux leg with a reflux line connecting to the intake of 4-inch heating coils. The 10-inch reaction chamber was connected with try cocks and a 2-inch residuum drawoff line which run to run-down tanks. The furnace consisted of two fire boxes, each fire box heating two banks of 4-inch heating coils.

This Dubbs No. I was operated with a continuous oil feed fed to the four banks of cracking tubes, and liquid residuum level carried in 10-inch reaction chambers being approximately half full, with approximately 100 pounds pressure carried through the system. The furnace temperature was maintained at
2306 approximately 1500 degree F. The length of runs was approximately four to six days. At the end of these runs we would find the 10-inch reaction chambers full of carbon; the 4-inch cracking tubes would have a good bit of carbon; the reflux leg would have carbon and mushy carbon; and the transfer line would have a good amount of carbon.

The carbon from the 4-inch cracking tubes was re-

2307 moved by means of turbine; and from the ex-
2307 1254 pansion chamber, reaction chamber, by the means of picks and hoes for dragging it out; the transfer line being cleaned with the means of turbine.

The carbon and slush from the reflux leg were removed by removing the flange on bottom of the reflux leg. The raw oil feed was introduced to the heating coil at the cold part of the furnace and withdrawn at the hot part.

The majority of the shut-downs on the Dubbs No. 1 plant was due to carbon in the 10-inch reaction chamber and the 4-inch heating tubes.

2308 After this No. 1 plant blew up, I continued in the employ of Universal at Wood River for approximately six weeks as an assistant to the engineer on construction of the new plant No. 1A. I was then transferred by Universal to their experimental plant at Riverside, Illinois, which was called Plant No. 2.

2309 This plant had one bank of 4-inch cracking tubes connected to a vertical expansion chamber 10 feet by 10 feet in size as contrasted to the No. 1 plant at Wood River which had 10-inch reaction chambers laid horizontal.

The expansion chamber of the Riverside No. 2 plant had six try cocks and three 2-inch residuum drawoff lines, which were connected to run-down tanks. Those

2310 try cocks were placed along the side of the expansion chamber running from the top to the bottom. They were to ascertain the liquid level in the expansion chamber. I assisted in the operation of this No. 2 unit at Riverside as an operator for approximately six months. During this period there were a number of runs made on this plant. These runs were ap-

2311 proximately four to six days long.

2311 1255 This plant was operated with a continuous feed of different amounts on different runs, and maintained at certain pressures with a liquid level maintained in expansion chamber by continual drawing off residue. The reflux from dephlegmator was returned to 4-inch heating coils through reflux leg and reflux line. The pressure was on the entire system and was from 100 to 150 pounds.

2312 At the end of these runs that I assisted in on this Dubbs No. 2 plant at Riverside, the 4-inch cracking

tubes always had a good amount of carbon, with reaction chamber being full of carbon. The 4-inch transfer line always had carbon in it, with the reflux leg having carbon and mushy carbon.

The carbon was removed from the 4-inch cracking tubes and transfer line by means of a turbine; from the expansion chamber by opening both top and bottom flanges, and using picks at first and in later runs by means of a cable. From the reflux leg it was removed by removing the flange from the end of the reflux leg.

In removing the carbon from the reaction chamber by means of a cable, the cable was placed in the re-
2313 action chamber during the shut-down previous to the heating up of the plant. It was placed in a spider-web formation, one layer about the other, these layers being approximately 15 inches apart, and on cleaning out it would be pulled from the bottom of chamber by means of a hoist. This would break the carbon up so that it would fall out of the bottom head. After that the remaining portion of the carbon was removed from the chamber by means of picks, mattocks and shovels.

In the furnace on this No. 2 unit at Riverside, the heat from the fire box went up through port
2313 1256 holes, over a wall separating the fire from the tubes, and down through the bank of heating coils, the 4-inch cracking tubes being placed in rows
2314 one about the other. The oil was fed to the cold part of the tubes at the bottom of the tube bank, and it came out at the top of the tube bank or the hottest part.

In the operation of this unit at Riverside, it was customary to watch for hot spots that might appear on the tubes. During the operation of this apparatus
2315 I observed hot tubes. As a general rule, the shut-down of this plant No. 2 was due to carbon in the top or hottest tubes which would cause hot spots due to the expansion chamber becoming full of carbon, and at times due to overheating of tubes, or tube blowout. This plant did not operate continuous during the six months I worked on it.

I was taken off of operations at the Riverside plant and sent by Universal to the Interocean Oil Refining Company at Baltimore, Maryland, as operating in-

structor on their standard 500-barrel Dubbs cracking
2316 unit, which was approximately the same as the unit at Riverside except greater capacity. The length of runs at the Interocean was approximately four to five days.

2317 The units at the Interocean were operated the same as the operations on the No. 2 plant at Riverside. The carbon at the end of the runs would be distributed in the 4-inch cracking tubes, transfer line, the expansion chamber and carbon and mushy carbon in reflux leg.

I remained at the Interocean approximately
2317 1257 two months. My next assignment was at the Prudential Oil & Refining Co., Baltimore, Maryland. I was employed there as operating instructor
2318 on a 500-barrel Standard Dubbs cracking unit. This unit and the operation of this unit were approximately the same as the one at the Interocean Oil Company.

As operating instructor I helped in the operation of the runs conducted in the plant there. I remained at the Prudential approximately two months, and then Universal transferred me to the Producers & Refiners Company at Parco, Wyoming, as an operating instructor on standard 500-barrel Dubbs units the same
2319 as the units at the Interocean and the Prudential, and having approximately the same operation. I remained at the plant of the Producers & Refiners Company about three months.

My next assignment was at the Ouachita Valley Refining Company, Eldorado, Arkansas, as operating
2320 instructor on a standard 500-barrel Dubbs cracking unit which was operated approximately the same as the other 500-barrel units I had operated. The work at this plant was experimental, to try and make a marketable fuel oil of the Dubbs residue. This was done by taking off a low gasoline yield, and proved not to be profitable, as the fuel oil couldn't be marketed on account of carbon and B. S., or bottom settlements, that is, a mushy sediment that was found in the residuum.

2321 Next I was sent by Universal to Wichita Falls, Texas, at the American Refining Company for a very short time, for observation of other operations.

In these various Dubbs operations that I have re-

ferred to, the residue was drawn from the re-
2322 1258 action chamber and run through a pipe coil condenser to run-down tanks. The run-down tanks would soon have a good deal of bottom settlings in the tanks which had to be cleaned from time to time. I had experience in the use of this residuum for fuel oil in these various plants. My experience was that it was very hard to handle in the fuel oil burners on account of carbon. The burners would become plugged up.

From the American Refining Company at Wichita Falls, I was transferred to the Kendall Refining Company at Bradford, Pennsylvania, as operating instructor. I assisted in the starting and operation of the
2323 standard 500-barrel units there for Universal.

While I was operating these units for Universal, the length of the runs was approximately seven to nine days. The operations were about the same as the other operations that I have explained. After these units had been operated by Universal, I left the employ of Universal and accepted a position as high pressure superintendent for the Kendall Refining
2324 Company. As superintendent, I had complete charge of operations of the Dubbs cracking units at Kendall.

The character of the charging stock on these units varied from time to time with different grades of fuel oil, running Pennsylvania light straw fuel and heavy straw fuel, Snodgrass residue and Dubbs residue. By "Dubbs residue" I mean the residuum as drawn from the Dubbs plant from the reaction chamber. The Dubbs residue was rerun through the Dubbs unit with a blend of 40% heavy straw fuel, 20% light straw fuel, and 40% Dubbs residue. The length
2325 1259 of runs that we obtained on this blend was from ten to fifteen days. We ran stock that didn't contain this Dubbs residue, but I did not notice any marked difference in the operation of the plant when we ran the blend with the Dubbs residue and when we ran without the Dubbs residue. We ran this Dubbs residue and blended it with the charging stock because we had experienced considerable trouble finding a market for this fuel oil, and when our storage tanks became full we had to do something with it; therefore, I ran it back through the Dubbs plant.

I remember a run that I made with this blend containing the Dubbs residue that I called to the atten-
2326 tion of Universal. DX 735 is a letter dated October 23, 1924, which I received from Mr. J. G. Alther of Universal.

2327 DX 735 reads in part as follows:

"I was just about to dictate a letter to you on another matter when your letter of the 20th to me was received. It is interesting to note that you are obtaining $12.50 a ton at the refinery for the coke produced from the Dubbs process. I assume that this is the coke just as it is taken out of the chamber, that is the lumps and fines.

"Another interesting item is that you are cracking 40% Snodgrass residue, 40% Dubbs residue and 20% straw colored fuel oil. What is this Dubbs residue which has a 24/26 gravity? Do you mean that this is our regular residuum drawn from the reaction chamber or is it pressure distillate bottoms?

"Considering the charging stock, I would say that you made a very nice showing in obtaining 41.89% gasoline of the raw oil, also considering that your figures are based on tank gauges.

2328 "I am sure that you will gradually get the fuel oil system working properly and satisfactorily. Of course, I can well appreciate that you are handling some heavy stuff. It is surprising to note that you found an accumulation of 5 feet of carbon in the tank. We are sure that these difficulties will gradually be ironed out."

2328 1260 "In this connection, I recall speaking to some of the boys who have been in constant touch with the fuel burning system at one of our licensees' plants where they claim that over a period of something like five months they cleaned out the two recirculating tanks once or twice and found very little accumulation. I am taking this question up with our Mr. Huff, who happens to be out of the city at this writing, with a view to having him make suggestions to you which might be helpful in eliminating this difficulty.

I cannot too strongly urge that the heat exchangers and flue gas circulating system be switched in as soon as possible as a tremendous saving in operating cost will be effected. This should be done as quickly

as possible to take advantage of the equipment which is now installed in Unit #2.

I certainly hope that conditions at the Kendall plant will be bettered very shortly now whereby both units can be run to full capacity and that they will install the reflux pump which has many advantages, such as increasing the capacity but mainly increasing the production of gasoline per day per unit. The pump installation will pay for itself many times, especially when you consider that where these pumps are being used they are getting at least 100 barrels more gasoline per day per unit, which otherwise would not be possible without the pump."

2329 1261 I do not have in my possession my letter of the 20th, nor a copy of it, which this letter refers 2330 to. I do not have in my possession a copy of any letter which I wrote in answer to this letter.

DX 736 is a carbon copy of a letter from Mr. Donald J. Bergman to Mr. L. C. Huff, under date of March 19, 1925, which has attached thereto three pages on report of run made with flue gas recirculation, a distillation of the stock and a distillation of the Kendall light and heavy straw feed and the Arkansas City pressure distillate bottoms. This carbon copy was handed to me personally by Mr. Bergman in March, 1925. In the upper left-hand corner of this letter in ink the word "Lon" was written on there by Mr. Bergman to show that the copy was mine.

2331 DX 736 reads in part as follows:

"The following is a short report on Run No. 9 of Kendall Refining Company Dubbs Plant No. 2 made with the flue gas system only.

"This run is especially remarkable in the length of run and the throughput which probably establishes a record. During the 505 hours on stream 10,142 Bar-

2332 rels of raw oil were fed to the plant. This is an average of 482 Barrels per day which is not bad for a 38.2° to 39.8° Be gravity charging stock. The gasoline yield averaged 43.19% of the raw oil, or 208 Barrels of gasoline per day on stream.

* * * * *

"This is the fourth run made with the flue gas system in operation. This system is giving very satisfactory results with no troubles of operation or maintenance. The per cent CO_2 in the flue gas was main-

tained at an average of 10.5% and the stack temperature averaged about 480° F.

2333 "The summary report and an average distillation of the charging stock is attached."

2334 DX 737 is a copy of a letter from Bergman to
2334 1262 Huff, which I received from Mr. Bergman through the mail at Bradford, Pa., soon after the middle of April, 1925. DX 737 reads in part as follows:

"The following is a short report on Run No. 10 of Kendall Refining Company, Unit No. 2, made with
2335 the flue gas circulating system and vapor line heat exchanger.

"The first part of the run was made on heavy mixed Snodgrass and Dubbs Residues with a gravity of about 30° Be. This was fed through the heat exchanger and thence direct to the tubes. During the latter part of the run, the feed was switched to a tank of Straw Fuel with a gravity of 38.5° Be and a portion of this was split overhead to the dephlegmator after being preheated.

"The total fuel per cent of the raw oil is 6.2% from firing and 5.45% on stream. These fuel rates are very low, due to the heat saved by the vapor line exchanger.

"The gasoline per cent of the raw oil is 37.1%. This is rather low on account of the low gravity of pressure distillate taken over. It would appear that the split feed of raw oil was vaporizing and being partly carried over to the condenser. The plant pressure was carried at 170 to 180 lbs. on the light oil, which may have helped to carry over the raw
2336 oil. The capacity of the plant also may be too high for the light oil.

"During the first portion of the run on the heavy residue oil with direct feed, the reflux ratio was 2.08. For the latter part of the run, on light oil, with a small portion of the raw oil split overhead the reflux ratio cannot be obtained exactly because an unknown amount of raw oil was fed direct. The amount of oil going through the reflux meter was 2370 g. p. h. on a 60° basis. During this time the raw oil averaged 950 g. p. h."

2338 The writing in the upper right-hand corner of this letter was placed there by myself at the time of the

receipt of the letter to identify the charging stock used in this particular run.

DX 738 is a distillation of Dubbs residue dated January 20, 1924. DX 739 is a distillation of Dubbs charging stock dated October 20, 1925. DX 740 is a distillation of Dubbs residue from Unit 2 dated March 2, 1925.

2341 1263 In these runs that were conducted at the Kendall Refining Company while I was superintend-
2342 ent of the plant, the carbon at the end of the run was distributed through the 4-inch cracking tubes, the transfer line, the expansion chamber would be full of carbon, the reflux leg would have carbon and slushy carbon, and it was necessary from time to time to clean the dephlegmator pans on account of carbon.

The operations at the Kendall plant were run on the continuous residual type operation. The raw oil feeds on the Kendall units were of different types, such as an overhead feed, split feed and a direct feed to heating tubes. I ran the unit feeding in all these various ways.

2343 The Kendall Refining Company sent me to the Vulcan Refining Company at Coraopolis, Pennsylvania, to observe operations of a Wilson-Snyder hot oil pump that they had installed on their units, with the view of obtaining information on hot oil pumps and the intention of installing same on Kendall units. As the result of this visit, I installed pumps on the Ken-
2344 dall units. By the use of the hot oil pump we were able to increase the capacity of the plant. We did not have any difficulties with this pump in its operation.

In this visit that I made to the Vulcan Refining Company I observed they had a screen placed in the residuum line at the run-down tank to remove hard particles of carbon from the Dubbs reside. I saw this in operation. As a result of seeing this, we at the Kendall tried the same principle, but placing it in our line close to the front before it had gotten to
2345 1264 the run-down tanks. We found that the screen would help some by the removal of hard particles of lumps of carbon from the residue, but the mushy carbon would still go on down to the run-down tanks. This mushy carbon would settle in these run-down tanks as had occurred before.

I stayed at the Kendall Refining Company a little over two years, until June of 1926. Next I went to the Ashland Refining Company, Ashland, Kentucky, for one year, as superintendent of their Dubbs stand-
2346 ard 500-barrell cracking still. This had a larger, 10 x 15 feet, expansion chamber and was equipped with a Byron-Jackson centrifugal single stage pump connected in the reflux line between the reflux leg and intake of 4-inch cracking tubes. During the time that I was with the Ashland, the operation of this pump was not satisfactory. This was due to the presence of carbon in the reflux which had a sand blast effect on the impeller and casing, causing these parts to wear or where the pump would either not pump or not pump sufficient oil to keep the 4-inch cracking
2347 tubes from overheating. This condition showed up after the pump had been in operation for about four months.

The operation of this plant at Ashland was about the same as the previous operations which I have described, except that we produced more coke due to the heavier charging stock used. The charging stock used was Kentucky fuel oil. The average length of run at Ashland Refining Company was four to five
2348 days. At the end of one of those runs the 4-inch cracking tubes, the transfer line, would have carbon in them; the expansion chamber would be full of carbon; with a good amount of carbon and slush in reflux leg.

1265 *Cross-Examination by Mr. Hall.*

2349 I first went to the Ashland Refining Company in June, 1926. About six weeks later, a Dubbs unit was installed and regular runs were made. The guarantee runs, the yields of which I do not know, were successfully made by the Universal Oil Prod-
2350 ucts men and I then took over the plant as an opera-
2351 tor of the Ashland Refining Company. The yields after Ashland took over were 37 or 38% of Regular Navy Gasoline. There was a pump in the reflux line at the time the guarantee runs were made. From the time that I took charge of the Dubbs unit at the Ashland Refining Company, it was run continuously.

The charge was Kentucky fuel oil, but I cannot remember its gravity.

2352 Whenever I referred to "runs" in continuous op-
2353 erations, throughout my testimony, I mean the complete cycle. On all the plants, except the Kendall Refining Company which was not operated continuously, when I referred to "length of time of run", I meant the complete cycle. As to Kendall it meant only the "on stream" period.

2354 I have been away from the refining industry for nine years, during which time I have been employed as a salesman of novelties and have done some steam fitting.

2356 PX 524 fairly and accurately represents the Dubbs 500 barrel plant with which I am familiar.

2357 PX 741 is my report to Universal, made when I was superintendent of the Dubbs plant at the Ashland
2358 Refining Company, regarding the run which ended about December 2, 1926. This report shows that the on stream time was 126½ hours and that
1266 a yield of 50% of Navy gasoline based on the charge was made.

2360-2361 I do not deny that runs were made on the Dubbs unit at the Ashland Refining Company in which the time on stream of 46½ hours and gasoline produced was 53.5 per cent of the raw oil.

2362 PX 742 is a report made by me to the Universal Oil Products Company showing a run of the Dubbs unit at Ashland Refining Company which was on stream 151 hours and produced a gasoline yield of 48 plus per cent.

2363 PX 743 is a letter I wrote to Mr. Bergman of Universal Oil Products Company on February 29, 1925, wherein I stated that the Dubbs operation at the Kendall Refining Company, a run of 18 days was made with the gasoline yield of 44 per cent or better. In that run, very little carbon was present in the
2364 tubes when we closed down. Dubbs operation at the Kendall Refining Company was about the same as the other types of Dubbs operation.

2365 DX 737 is a report of a run at Kendall Refining Company wherein a mixture of Dubbs residue, Snodgrass and light straw oil was run as the charge. During that run, residuum which was withdrawn was

returned to the system through the charging stock. The residuum was cooled and went to a rundown tank where it remained until we had a charging stock
2366 tank to be filled up. This run was made the latter part of March and the first part of April, 1925, and
2367 was on stream 158 hours producing a yield of 37.1% gasoline. The charge was 30 to 39 Baume. The
2368 residuum gravity was from 18 to 27 Baume. The gravity of the heavy straw oil charge was approximately 38 and of the light straw oil, approximately
2369 40. The gravity of the Snodgrass residuum was
2370 1267 approximately 28. The first part of the run had a charge of straw fuel oil and Snodgrass and Dubbs residue, which was approximately 30 to
2371 32 gravity. The gravity of the residue produced during that run was 24 to 26. Charging stock for the second part of the run was light and heavy straw fuel having a gravity of 38 to 39 degrees. Residuum of the second part of the run was approximately 27° Baume. I had charge of the run referred to in DX 737. Mr. Bergman was present at that time.
2372 This run was a test run to try out the effect of the line heat exchanger and a flue gas circulating system. I do not know how many runs of this type were made.
2373 The flue gas circulating system at Kendall was
2374 first used on Run 9, plant 2, on March 1st, 1925. Before the flue gas circulating system was installed at Kendall, a run of 18 days on stream was made and was only shut down because of defective tubes, otherwise it could have run 3 days longer.

I was a stillman's helper on the No. 2 Dubbs unit at Independence, Kansas, when runs were made for
2375 the benefit of a committee of the Western Refiners.
2376 The only name I now recall of those in attendance at this run of the Dubbs No. 2 still at Independence is Dr. Cross.

2377-2378 In the Dubbs 500 barrel unit, a fair difference between the receiver pressure and the pressure on the tubes is approximately 25 pounds.

1268 Roxana Dubbs Unit No. 1: I remember the length of runs on this Dubbs No. 1 unit because of the discussions with the company officials
2379 regarding this run. The discussions took place about 1922 with L. O. McNally, George Sims, Joe Campbell,

2380 Bob Crowe, and Slim Atkinson.. I cannot remember the yield or the character of the charging stock of those Roxana runs or how many runs were
1269 made before the still blew up. I was fireman
2381 on the Dubbs No. 1 still at Roxana. Mr. C. P. Dubbs and Mr. W. F. Sims had charge of the operation. I cannot recall the length of the longest run or
2382 of the shortest run or how much they varied.

The length of the Dubbs run at the Interocean Oil Refining Company at Baltimore was approximately four to five days. The longest run was a seven day
2383 cycle. I cannot recall the charging stock used nor how many runs were made. There might have been runs longer than seven days. I was only there during part of the period they were making the guarantee runs.

I was at the Prudential Oil & Refining Company
2384 approximately two months. I cannot recall the approximate number of runs that were made at that time. The Dubbs plant first made its guarantee and then it was delivered over to the operators of the Prudential Oil & Refining Company, after which I left. I don't know the length of the longest run, the
2385 character of the charging stock or the gasoline yield.

I was not at the Producers and Refingers at Parco, Wyoming, after the Dubbs still had met the guarantee. The longest run was 15 days. I cannot recall the character of the charging stock or the gasoline yields. I was at the Ouachita Valley Refining Company at Eldorado, Arkansas, for about two months
2386 which was only during the guarantee period. The stills were operating when I left and were being run by the Universal Oil Products man Bob Crowe. I cannot remember the characer of the charging
1270 stock or the gasoline yield. The oil temperature was approximately 850° F. I do not know the pressure.

2387 I was at the American Refining Company at Wichita Falls about two weeks or less. They have six Dubbs units operating there. I do not know the
2388 yield, the character of charging stock or the on stream period of the Dubbs plants.

Kendall Refining Company Dubbs Units: In some of the runs at Kendall, gasoline and kerosene were

found in the residue. According to DX 738, six per
2389 cent of all gasoline and forty-six per cent of kerosene, and an unknown amount of gas oil was in the Dubbs cracked residue recharged to the Dubbs units. According to DX 738, eighty per cent of this residuum
2390 boiled at 700° F. or lower. According to DX 740, eighty-two per cent of the residuum boiled at 700° F. or lower. The pans in the dephlegmator of the Dubbs unit at Kendall were cleaned about every three months. No analysis was made of material removed from the dephlegmator to ascertain its character.
2391 In the 500 barrel Dubbs unit, the charge was fed directly or to the top of the dephlegmator or was a split feed. Kendall had a split feed and overhead feed.
2392 In the runs of the standard 500 barrel Dubbs unit, coke chamber or vapor separating chambers were approximately filled with coke when we shut down.

1271 *Cross-Examination.*

1055 PX 519 is a diagrammatic picture which represents the Dubbs No. 2 run at Independence for the benefit of the Refiners' Committee. It accurately represents this operation with the exception that I do not remember that there were two dephlegmators. I can-
1056 not say the two dephlegmators were not there, but
1057 I do not recall them. In the Dubbs No. 2 operation at Independence the reflux was returned from the coil marked "aerial coil" and was charged to the heating coil in admixture with the charging stock.
1059 I know that carbon was taken from the system at the end of the run but I do not know how much
1060 the carbon weighed. I remember that the carbon was removed from the tubes separately and weighed so as to determine the amount of carbon in each tube.

PX 597 are the run sheets for the nine-day run on the No. 2 Dubbs still which was operated at Independence for the committee appointed by the Western
1061 Refiners' Association. My name appears on these run sheets. Mr. W. F. Sims had charge of the run.
1062 These run sheets show that this run was fired at 9 P. M. July 19, 1919. PX 597 shows that the on-

stream period for this run commenced at 12:22 P. M. July 20, 1919 and ended at 6 P. M. on July 28, 1919. The charge for this run approximated two to three gallons per minute, as I remember.

1272 *Redirect Examination by Mr. Thiess:*

2392 The long run of twenty-one days at the Kendall Refining Company was obtained on account of the exceptionally good charging stock.

On PX 743, I do not know what the character of the charging stock was that we used when that run was made.

1273 *Recross Examination by Mr. Hall.*

2393 DX 736 is a report on a run on a Dubbs unit at
2394 Kendall which was 21 days. On that run, the charg-
2395 ing stock was a mixture of light and heavy straw fuel oil on an average of 40° Baume. No residuum at all was used in this run. The yield of gasoline was 43.19% on the charge.

1274 LUIS DE FLORENZ*, Pomfret, Connecticut:

Direct Examination by Mr. Thiess.

2568 I am a consulting engineer. My attendance here today is in response to a subpoena.

I designed and supervised the construction and operated a vapor phase cracking plant for The Texas Company at Bayonne, New Jersey in 1916 or thereabouts.

I was in charge of operation of the plant and trained all the men until I left the plant due to illness.

2569 The plant was completed in 1916, and operation started as soon as completed in late 1916 or early 1917.

2570 There is a flow sheet showing how this plant was built and operated that is fairly accurate in one of Redwood's publications.

* Deposition given April 12, 1940.

2571 (Thereupon, on account of controversy as to this flow sheet shown in the book, Mr. Schneider, one of
2572 the attorneys for The Texas Company, was thereupon put on the stand to establish the fact that the records of The Texas Company regarding this Bayonne operation were produced for the inspection of both plaintiff and defendant in this case prior to the taking of Mr. DeFlorez' deposition, and Mr. Schneider was asked further if he had among those records any flow sheet of the Bayonne operation, and he said that he had not any that were completely accurate. And then he produced one that, with certain corrections which the witness DeFlorez subsequently made in his testimony, he said was accurate.)

2574 1275 There has been so much discussion as to whether DX 623A with the corrections made by Mr. Schneider illustrates the operation of the vapor phase process at the Texas plant which I supervised, that I would like to put it this way:

All pressures which I used on the converters in all
2575 the Hall plants were based on inlet to the tubes. I had a central control panel, and on that central control panel was a pressure gauge equipped with two hands, one measuring the fore pressure to the panel, that is the pump pressure, and the second measuring the pressure at the inlet to the converter. The difference between those two pressures gave me an index of whether I had carbon in the tubes or not. I only used the inlet pressure for operating control.

With the correction that has already been made, DX 623A is substantially the flow sheet at Bayonne.

The charging stock came from a storage tank, of which I make a small illustration D. An arrow shows the direction in which the oil flows.

The oil flows then to pump F, and thence to a tank G, which was used as sort of an equalizer for pres-
2576 sure. From this the oil flowed into a filter H. From thence the oil flowed through a control valve I, and through a meter J. From the meter it went through an oil heater of tubular nature K. The oil passed through tubes and was heated on the outside by exhaust steam from the plant. The oil then flowed into inlet of the coil of a converter or furnace L. The

oil entered the rear of the converter at the coolest end of the coil at M.

2576 1276 The oil passed in series through the coil from a cooler zone to a hotter zone and was discharged at a point N. It entered an enlarged pipe O, and passed into a column P, through which it flowed downwardly. On reaching the bottom of this pipe
2577 the flow of hydrocarbons passed horizontally through a connecting pipe Q. It then entered another vertical column R, and then passed outward from the top of this column through a pipe S, into another column T, entering at the base of this column T. The flow was upward through this column T, and out through a pipe U, through a cooling coil or condenser V, into a separating pot W.

At this point the liquid products were separated from the gaseous products, the liquid passing out through a line X, provided with a seal and a look-box Y, and into a tank marked "Spirit Sump" Z.

The gases flowed out of the pipe AA and entered into the compressor BB. The gases were compressed and discharged into a pot CC. A pump marked DD picked up the liquid products from the spirits sump Z and discharged them into the connecting line be-
2578 tween BB and CC. Together these products flowed out of the pipe EE and thence through coolers FF. From thence the products flowed into another pot GG, and from this pot they flowed through a line HH into a receiving tank marked II. There are valves JJ above the pot GG, which permitted blowing off the unit to the tanks directly without passing through this receiver. In operation the products were passed through the receiver and passed out of the receiver at the top KK. The liquid material left behind in this
2578 1277 tank and fixed gas was passed through the line KK into the gas storage tanks LL.

The purpose of the tanks LL was to furnish a reserve supply for the burners to heat the converters. These tanks were maintained under pressure and the pressure reduced to the outlet line MM, and which on this diagram is marked "To gas burners." At times there might have been a small amount of con-
2579 densate in these tanks which could be removed by the lower lines NN. There probably were valves underneath the tanks.

The filter H was exceedingly useful in the beginning of the operation of the plant, because at that time there is always an opportunity for dirt and scale to get into the pipes. That filter was to take out those particles so that we did not have any trouble with the needle valves at the entrance of the liquid.

2580 The hot vapors came in through the pipe O into column P and coursed downward and then across. We had vapors in the column. At the beginning of the run we sometimes withdrew liquid, and when the run was under way we did not draw anything from column P. There was nothing in the column P. The vapors entered the column R and went upwards through some trays made out of perforated grids. There was a water coil at the top for cooling. The material, still vapor, passed out of the pipe S and went onward.

The entrance of this cross over Q was above any liquid level maintained in that column R. The liquid in column R was drawn off both continuously or

2581 intermittently. We tried to draw it off continuously, but sometimes we did not. We had to draw

2581 1278 down at times. We were very careful not to let that liquid get out, because we thought that would prime the column and throw over.

We did not return the liquid that we withdrew from column R. We might have returned it to distillation, but we did not have that operation. This is essentially a once-through process. The liquid drawn from that column R was a residual material, pretty black. At times, depending on what kind of oil we started with, and how much we cracked, the material was more or less black and heavy.

Column T was a bubble tower. I had thought that

2582 we would get a better separation with this type of construction and put it in at Bayonne. I must confess that I omitted to add any reflux. There was a small cooling coil OO at the top to produce condensation to wash the trays; but it was not sufficient to do that, and this column acted as a more or less pack tower rather than a bubble tower.

We withdrew liquid from column T through outlet QQ. It was a residual material but somewhat lighter and better color than the material drawn from R

2583 through PP. We put the material that was withdrawn from T in a tank. We got rid of it one way or another, and if we wanted to make any runs on it again we redistilled it because it would give us trouble in coking the converter if we ran it as it was. That stock was too dirty for this operation to run at high temperatures. The purpose of distillation was
2584 to take out a small percentage of tar that was in the material and carried over. We dropped out
2584 1279 probably 5 to 10 per cent of the material, and the balance was fairly clean stock and could be run.

2586 Photograph DX 746-A is a construction picture of the converter house. DX 746-B is the same, later. DX 746-C shows the charging pumps, the receiving tank and, in the lower left-hand corner, the filter. DX 746-D shows the central control panel, the meters below; the pressure gauges for fore-pressure, and inlet converter pressure; and the next row, the others were similar gauges and other gauges and a clock at the top.

DX 746-E shows the heaters which I have spoken of for pre-heating the oil on the way to the converter with steam. DX 746-F shows the initial construction of the battery of converters, and illustrates the bonding of the bricks. This is a view from the end of
2587 the battery of four converters, looking down on them from a height of about 6 feet. That shows the bottom of the converters. It is the initial stages of the building of the converter bank.

DX 746-G again shows the converters in construction and nearly completed. In this instance the tops are shown with the tube-supporting castings in place, marked "Tube supports." DX 746-H gives another view of this same subject, taken at approximately the same time. DX 746-I shows the tops of the converters when completed; the plant was in operation at the time this photograph was taken. The apparatus A on DX 746-I is the outlet pipe which connects the converter outlet N to the column P, and corresponds to the pipe marked O, referring to DX 623A.

2588 1280 There is no pressure gauge shown on this pipe. These pipes were an outer casing and an inner pipe which could be removed for cleaning. That

is also shown on DX 623A, and it is marked Detail B. The pipe O on DX 623A contained a small pipe which was removable by removing the flange at the end, and could be slipped out for cleaning, if necessary. The flow of material was through the inner pipe and there was a packing in the annular space between this pipe and the outer one.

DX 746-J shows a front picture of the converter setting before the completion of the combustion chambers. DX 746-K shows the completed battery of converters with the automatic temperature control valves, taken while the plant was in operation. DX 746-L
2589 shows one side of the control room with the electrical switchboard and the electrical apparatus used to operate the fuel valves.

DX 746-M shows the compressor referred to as BB in DX 623A. DX 746-N shows this same compressor when completed and equipped with the automatic pressure valves. DX 746-O shows some auxiliary pumps used for transferring oil.

The inside diameter of the tube used in the con-
2590 verter was one inch. The tube length was 640 feet. The column T of DX 623A was about 10 feet in height and 3 feet 6 in diameter. The other columns P and
2591 R on DX 623A were about 12 feet in height and 2 feet in diameter.

The pressure in front of the meters was about 150 pounds. The pressure after the control valve I, which would constitute the inlet pressure to the converter, was of the order of 90 pounds. The pressure
2591 1281 in the pipe O to the dephlegmating system was maintained at about 2 pounds by the automatic arrangement on the compressor BB. We never knew what the outlet pressure was at N except that we knew it to be much lower than the inlet pressure.
2592 The temperature of the material at the outlet of the tubes was of the order of 600 degrees Centigrade, and in Fahrenheit would be of the order of 1100 degrees. That is illustrated and taken by the pyrometers T, which may be seen in DX 746-I.

I cannot give the temperature in the various dephlegmators P, R, and T approximately, except that the outlet of the last column marked T was of

the order of 200 degrees Centigrade or 400 degrees Fahrenheit.

In this construction at Bayonne there were four
2593 converters or furnaces, each having having a set of columns as is illustrated on the drawing DX 623A, i. e., a completely separate system right through to the look-box; four independent units. They were encased in an outside wall, but they were entirely separate in every sense of the word.

Kerosene or low-grade kerosene known as petrolite, or something of that nature, for the most part was the oil that I charged to the coil in this operation. It was a transparent, nearly water-white stock. There were experiments made charging a gas oil of a 32 or 34
2594 gravity, yellow in color, and experiments made charging this so-called light residue. We charged the gas oil as was. It was not given any treatment prior to charging. That was a distillate that we charged.

The plant ran fairly continuously, and I be-
2595 1282 lieve that I operated the plant some three or four months before I was taken ill.

As long as I stuck to kerosene I had no carbon trouble at all in my tubes. Any time I tried to put in either this light residue or material of the order of gas oil, I had trouble if I tried to make anything like the yields I could make on kerosene.

The yield was of the order of 30 percent on kerosene. We never could get anything like that on the other stocks without carbonizing fairly rapidly. I do not remember what my crack per pass was on the
2596 other stocks. I had made some experiments a long time before that in England, and I found I could not run those things and I was not very keen on repeating those experiments. It just made a lot of work, and I had undertaken to run this plant on kerosene-like material and wanted to stick to it.

I made one run on kerosene for about two weeks continuously which was very satisfactory and no shut-down for carbon.

2597 I consider that the vapor phase plant at Bayonne was fully operative. It illustrated very well the fact that you could run kerosene; and so far as a high temperature once-through process, I think it was a good job.

2598 The plant would run about 500 barrels a day, and I had it running pretty continuously. The product or distillate that I obtained in the operation was yellow, it was highly unsaturated, it had a bad odor; in other words, it was typically a vapor-phase product as we knew it in those days. We shipped this distillate to Port Arthur. I understand they tried to re-
2599 fine it at Port Arthur. I imagine they found it
2599 1283 difficult to refine, because it was different from other classes of stock.

I left the plant the latter part of April, 1917, after operations of probably four or five months, when I became ill.

I did not make any attempts with this process at Bayonne to make benzol or toluol. The Texas Company made such experiments after I left.

I assume that this plant was discontinued at the
2600 plant of The Texas Company because they did not think it would pay. There was a tremendous feeling against making so much fixed gas. We made a large amount of fixed gas, nearly 25 per cent of the material was gasified, and the non-liquid recovery was the thing, I think, that boosted the cost, and the fact that they had to run fairly light stock, probably is the answer.

2604 DX 747 are log sheets marked "Bayonne, New Jersey," and the date is January 25, 1917, "run No. 24."

2605 These log sheets cover a period of about 12 days, and the operation of this run 24 was a continuous run of about that length of time.

The date of that run was about January 25, 1917, to February 5, 1917.

2606 Note: DX 626 is a report on this run and gives (p. 4) the following tabulations and summaries of results:

"Run #24

		Gravity	Percent
Water White	250,106 gal.		
Crude motor spirit or naphtha distillate	130,544 gal.	53.1	52.2
Light residue	87,683 gal.	41.3	35.0
Heavy residue	1,624 gal.	39.8	0.6
Gas & Loss	30,305 gal.	——	12.2

2606 1284 "Crude Motor Spirit or Naphtha Distillate

(Averages)

Gravity	53.1	
Distillation:		
Boils,	27°C.	(80°F.)
Below 100°C.	(212°F.)	12.4%
150°C.	(302°F.)	26.9%
190°C.	(374°F.)	53.6%
End point	254°C.	

"Gasoline of 374°F. end, total production, 69,537 gals."

2614 Referring to DX 623A, the material entered the
2615 point M as a liquid. It left the coil at N, presumably as a vapor. The cracking occurred somewhere in the coil, toward the fore part, in the front end of the coil, i, e., downstream side of the coil near the outlet. There were probably some tar particles that apparently followed through, and I never knew, but in all probabilities vaporization was as complete as we could
2616 get it. I think vaporization is the step in which a liquid passes into a vapor stage and where there are two phases in existence during that step.

2617 Testimony under the rule:

"Q. I would like to call your attention to your testimony in the case of Gasoline Products *vs.* Champlin, beginning at page 459 and ending at page 460, in which you gave the following testimony:

"'Would you give me any indication as to the vaporization in the various parts of these coils and what it was? A. The matter of vaporization with—if you would make a question as to perhaps what is vapor at certain points, I would try to estimate it for you.

2617 1285 "'Q. Mr. De Florez, what do you understand by vaporization? A. By vaporization I understand the step of making oil into vapors such as we get when we boil water.

"'Q. It is the generation of vapors is it not? A. It is the generation of vapors, yes, sir.'

"Is that definition of vaporization correct?

2621 "A. This refers to an example of boiling water at atmospheric pressure, and in that case the thing is simultaneous and not two phase, merely transferring some of the water into vapor. This is a more localized. I tried to disclose to you—

"Q. You have no quarrel with that definition as there given?

2622 "A. I think this only applies to water here. This applies to water, just giving a specific example, is that right?

"Q. We were talking about the vapors of oil in 2623 the tubes, at the time, were we not?

"Mr. Thomas: Same objection.

"A. Regardless of what we had been talking about, I direct your attention to the fact that I discussed the boiling of water here.

"Q. Well, do you make a distinction?

"A. Such as we get when we boil water. That is an example of one vapor, but this where you are transferring the liquid into vapor. And in that case the generation of these vapors is premised with my general definition.

"Q. In other words, your understanding then of vapors is the change of state from liquid to vapor?

"Mr. Thomas: Same objection, and further objected to as leading.

"A. My concept is the change of state provided there are two phases. That is a step of vaporization. You go through those two phases.

"Q. What two phases have you in mind?

1286 "A. Liquid and vapor simultaneously present.

2624 "The Court: That all has to go in under the rule."

End of Testimony under rule.

2625 My next contact with my work at the New England Refining Company's plant at Fall River, Massachusetts, started April 1, 1919. I designed and built a lot of equipment at Fall River, and among that equipment I built a vapor phase cracking plant, con-2626 sisting of 8 furnaces similar in construction to the Bayonne furnaces, but not the same. There was an expansion tank on the end of the coil and then a condenser.

Oil was pumped through suitable regulating means, through these coils and heated to temperatures on the order of 1050 to 1100 degrees Fahrenheit; all was condensed, the gas withdrawn, and the products
2627 redistilled in the main plant. This operation produced a synthetic crude. No attempt at separating the products into various residues and distillates in the system was made. It was high temperature and low pressure, relatively low pressure on the outlet, i. e., 15 pounds.

The plant was used for 6 or 8 months. We had a very high gasoline market in those days and we could make money with a plant of this character. We got paid nearly 30 cents a gallon at the refinery for gasoline at that time.

2628 The charging stock was a kerosene distillate. This was a once-through operation and the yields were of the order of 30 per cent, based on the charge,
1287 and varied 25 to maybe 32. We recovered the yield afterwards on redistillation.

2629 The product that I made at this Fall River plant was a typical vapor phase product, foul and hard to handle except in connection with distillation and treating of other material with which it was diluted.

"Q. Was there any other well recognized type of cracking process having the general classification and name of commercial operation as of 1923, as compared to the vapor phase?

"A. There was the Burton process and others.

"Q. Well, was there a general classification given to this type of process, distinguished from vapor
2630 phase?

"A. They were generally called liquid phase, but I hope that you are not going to put too much weight on these definitions, because they were definitions of people that had to find terms and coin terms, and the terms liquid phase and vapor phase are not necessarily descriptive of what was inside the process."

As of that date those classifications were well recognized,—the classification of vapor phase and liquid phase. I naturally so recognized it at that time.

"Q. Mr. De Florez, what was your opinion as of 1923, as to whether a vapor phase process was given a

proper opportunity for commercial operation as compared to the liquid phase process?

2633 "A. I have no particular objection, Mr. Thiess, in answering any question of opinion, but I would like to get this thing through, and I would like to stick as far as possible to what I am required to answer, and unless there is good reason why I should go into it, I prefer not to, purely from that angle. I would just as leave give opinions as far as possible, but I prefer not to, because it just complicates things. I just prefer not to go into subjects that I do not have to go into, and I hope somebody will tell me whether I have to or not.

2633 1288 "Q. Disregarding the question of opinion, at the time that you were working on vapor phase
2634 at Bayonne and at Fall River, was the same amount of attention being given to vapor phase as it was to liquid phase in the art generally.

"A. I would prefer not to enter that subject, because it will complicate things; not that I am not willing to give these answers, if they are required, but I would prefer to limit the testimony just as much as possible."

DX 750 is an article appearing in the "Refiner and Natural Gasoline Manufacturer", entitled "Using
2635 Vapor Phase Process to Crack", written by me in 1923. In part it reads:

"The many processes now in use may be divided into one or the other of the following categories: viz, Liquid Phase and Vapor Phase.

"In the Liquid Phase Process, the charging stock is treated, as the name implies, in the liquid state, this being effected by keeping it under high pressure to prevent vaporization. The second classification comprises processes which vaporize the charging stock first and then superheat the vapors to cause the necessary cracking.

"Practically all the Cracking Plants in commercial operation today are of the Liquid Phase type, this being due to the fact that it is best suited to handle the heavier gas oils, which constitute the greatest portion of the charging stock available. Few plants, if any, of this type, operate commercially on kerosene distillates, owing to the necessity of carrying exceedingly high pressures to obtain proper results.

"Vapor Phase plants, however, can operate independently of pressure and can readily be adapted to run light charging stock, providing of course, that they are properly designed and operated. It is perhaps the lack of necessity for plants of this character which has retarded their development more than their existing shortcomings, which can be readily overcome, or at least compensated for, by natural advantages. The writer has found in the course of his experience that clean distillates above 36° Be. gravity can be treated without difficulty by the Vapor Phase apparatus, and that this apparatus can be constructed for the lowest unit cost. With regard to its
2635 1289 operation, the carbon formation when properly handled, is negligible and the losses in noncondensable vapors when operating in connection with a refinery, are moderate. • • •

• • • • •

"An important feature is the placing of the meters and all instruments on one board where they can be watched by one man who controls the whole operation.

"The whole success of the operation in Vapor Phase, is the exact control and maintenance of the right conditions for cracking. Temperatures and pressures will fluctuate almost instantaneously when treating the oil in the gaseous state, since there is not the inertia of the liquid to fall back on as in the case of Liquid Phase operation; this necessitates recourse to special apparatus for regulation.

• • • • •

"The product made by this plant is yellow, unsaturated and difficult to refine. It does not, however, cost more than 1/2 cent a gallon to redistill, treat and steam still, and therefore, such difficulties as may arise from the refining, are comparatively unimportant. As far as refining is concerned, it is admittedly an inferior product to the pressure dustillates obtained from high pressure apparatus, but as a fuel in an internal combustion engine, it is more efficient and it will furthermore very materially decrease the propensity for knocking in straight run product, when mixed with it to the extent of from 5 to 10 per cent. It has been found most desirable to treat it with straight run naphtha and when present in quantities

of the above order, there is little difference in the reaction.

* * * * *

"It is hoped that this article may call attention to the possibilities of cracking with Vapor Phase, for it is certain that if only a small portion of the energy which has been expended on perfecting Liquid Phase apparatus, is applied in the direction pointed out, very useful developments will ensue."

2638 DX 751 is an article in the National Petroleum News, December, 1927, presented before the American Petroleum Institute at Chicago in December. I am the Luis De Florez who wrote this article. In part it reads:

1290 "The use of pressure to maintain materials in the liquid state has been resorted to in the past, as it was found that oils cracked more readily at lower temperatures in the liquid state, and that low temperature cracking resulted in the production of a more saturated gasoline and a minimum of non-condensible products.

"Operating at temperatures of the order of 1000 degrees Fahr., there no longer appears to be the same necessity for maintaining the material in a liquid state to accelerate cracking, and the character of the gasoline appears to change more with respect to the temperatures than the pressures employed, thus, although the application of pressure may somewhat reduce the formation of non-condensibles, it no longer serves the purpose originally intended.

"The use of high temperatures with corresponding high pressures to maintain liquid conditions in cracking would multiply the mechanical problems and the usefulness of a process embodying these characteristics would seem doubtful unless unusual developments resulted. It appears probable therefore, that liquid phase cracking will continue to be practiced at comparatively low temperatures, and since no gain exists in operating vapor phase except at high temperatures, we certainly may expect operations of this character to be carried out at the higher ranges. Thus we might conceive of a practical division between liquid phase and vapor phase cracking as being made by the temperatures employed, and we would not be far wrong although somewhat inaccurate, in classify-

ing the usual liquid phase processing as a cracking operation carried out below 950 degrees Fahr., and vapor phase as that carried out above this temperature. We might even go so far as to characterize liquid phase cracking as low temperature cracking and vapor phase as high temperature cracking.

"The important economic difference between vapor phase and liquid phase cracking, as usually practiced, is found in the difference in the chemical structure of the gasoline produced by these different methods. Thus, in considering the commercial development of the vapor phase process in competition with established methods, we are concerned essentially with the desirability of producing the character of gasoline formed at high temperatures, in which the paraffine hydrocarbon content is comparatively low, and in finding a means to accomplish this at a reasonable cost.

"The original development of liquid phase cracking has been brought about by the desire to develop a process which would produce a gasoline resembling as closely as possible that obtained from normal
1291 distillation and effecting this with the least shrinkage of liquid products. This line of development has been the logical one, due to the fact that heretofore no commercial advantage existed in manufacturing a high temperature gasoline, and the only outlet for the gas produced in cracking lay in its utilization for plant fuel. Economic conditions which have influenced this development have changed, however; gasolines made under high temperatures have been found to possess marked anti-knock properties which are becoming a requisite to modern motor fuel: and the expansion of the oil industry has developed many contacts with other fields which should facilitate the disposal of non-condensible products for purposes other than fuel. It is necessary, therefore, to consider high temperature or vapor phase cracking in the light of new circumstances which have materially altered the outlook, and to readjust our ideas accordingly.

* * * * *

"Liquid phase cracking proved itself better suited to the then existing conditions of the refining industry, since a larger portion of the products obtained

could be handled in the usual channels while the demand for anti-knock fuels, which we expected to develop rapidly, did not materialize for many years. As far back as 1913 we made tests with vapor phase fuel in motors of fairly high compression which were then operated on 'Shell' and 'Pratt'—'No. 1' and obtained excellent results. The subsequent commercial development of motors, however, tended toward standardizing on lower compression ratios and our work, in the light of present knowledge, turned out to be premature. Without the demand for this type of product and without facilities for the disposal of gas, the time was not ripe for the commercialization of vapor phase cracking.

"In recent years vapor phase cracking has not appeared in a very favorable light due, in no small measure, to the fact that many semi-technical men discovered time and again that oil could be cracked rapidly under vapor phase conditions. This resulted in the promotion of many unsound processes and in expensive attempts to use them without realizing their limitations and the fact that, even if mechanically perfected, they would have to compete with established and efficient liquid phase plants without provisions to overcome their shortcomings or capitalize their advantages. Lack of technical knowledge and disregard for economic conditions have been the cause of repeated failures which have given the impression that vapor phase cracking was little short of a commercial impossibility.

1292 "In all forms of pyrogenic cracking, non-condensible gases are formed and by nature the gasoline made requires special and sometimes drastic treatment to meet present day specifications. These inherent characteristics are intensified in vapor phase cracking and have been stressed as basic disadvantages as compared with other forms of cracking. A high yield of non-condensible gas can be called a disadvantage, however, only as long as this gas is accounted of little value; and similarly the production of gasoline containing a high proportion of compounds requiring special treatment, can be considered a disadvantage only if it has no commensurate advantages over the usual product. As a matter of fact, if a reasonable price could be obtained for non-con-

densible gas, and a useful function served by most of the offensive compounds, these defects would disappear.

"The non-condensible gas produced by vapor phase cracking has a very high heat value as well as illuminating properties and is similar in almost all respects to the gas that is produced in retorts by gas companies to enrich water gas. It is conceivable therefore, without much imagination, that gas companies would be willing to buy this gas from the oil companies at a reasonable cost instead of purchasing gas oil which they, in turn, must process at considerable expense and plant investment, to serve the same purpose.

"It is further conceivable that refineries, which are situated within reasonable proximity to large centers of population, could afford to operate vapor phase plants, selling the gas as one of the resulting products to public utility companies, and actually make it a source of revenue. Possibly some desultory attempts have been made to work out arrangements of this character, but if only a portion of the effort which has been devoted to the sale of refined oil had been put on the sale of gaseous products, a ready market would doubtless exist for them today. Heretofore there has been little necessity to consider this problem seriously due to the comparatively small amount of gas formed in existing liquid phase plants and it is only natural that development should await the necessity. The only apparent obstacle to the profitable sale of gas appears to be the necessity of creating a true realization of its value.

"The success of a vapor phase operation does not depend primarily upon the reduction of the yield of gas beyond a certain point but upon its disposal at a reasonable profit. A high yield of gas affects the operation unfavorably only when it reduces the gasoline capacity, which may be the case in an inefficient plant where the ratio of gas to gasoline is excessive.

A rough figure for gas production can be taken
1293 as 100 cubic feet per gallon shrinkage of liquid products and its cost computed on this basis. It is probable that even if sold on a 'break-even' figure with charging stock, the cost of operating a vapor phase plant would be very reasonable, since the rapid

cracking which takes place at high temperatures will make it possible to process oil with less investment per unit capacity than with other methods of cracking.

"Another outlet for vapor phase gas may lie in its use in the manufacture of solvents. It is possible to make alcohols and kindred solvents by sulfation of still gases and much work has already been done in this field. The yield of solvents from still gases is largely dependent on the extent of their unsaturation and the vapor phase gases, which are very much more unsaturated than ordinary still gases or those obtained from liquid phase cracking, constitute a better raw material since the volume of gases processed is less per unit of solvent produced. The increase in demand for lacquer and paint solvents indicates possibilities for these products and, although their market is comparatively limited, some amount of vapor phase gas can be profitably absorbed in their manufacture. This outlet might be utilized where the sale of gas is not possible, due to the location of the plant.

"The distillate produced by vapor phase cracking has a very distinct advantage over straight-run product and liquid phase gasoline in that it has very marked anti-detonating properties. It presents a somewhat more difficult problem in refining but the growing demand for anti-knock fuels distinctly warrants some additional effort to produce a fuel which has these valued properties.

"Most anti-knock gasolines are being sold at a premium today, presumably to defray the additional expense in manufacture. A fraction of the average premium would be sufficient to pay for the additional cost which might be entailed in refining vapor phase material. The refining, which may appear to be difficult in the light of present knowledge, will inevitably improve from time to time if it becomes a daily operation, bringing about economies which will offset lower sales return, if the time comes when premiums are no longer in existence.

"In summarizing the economic aspects it may be said that vapor phase and liquid phase cracking are not directly comparable since they produce different types of products. Vapor phase cracking is capable of producing a highly anti-knock fuel and in so doing

produces a larger proportion of fixed gases than
1294 liquid phase and a commercial outlet must be found for this gas to make the operation profitable. An outlet exists in its use in the gas industry where it may replace the use of gas oil for enriching. This substitution would result in economies both to the refiner and the gas companies by the fact that the gasification and cracking can be carried out in one operation permitting an overall reduction of fixed charges and operating expenses and yielding liquid products which can be handled in the usual refinery channels and entirely gaseous products for the gas industry. This arrangement can be effected by choice of location for vapor phase plants and where this is not possible a secondary outlet may be found in the use of gas for the manufacture of solvents. It is not to be expected that vapor phase cracking will supersede liquid phase, but it has a distinct function in supplementing existing operations to enhance the production of anti-knock fuels by furnishing a blending stock.

"The mechanical aspect of the vapor phase problem leads us first into a comparison of the general type of plant required for liquid and vapor phase cracking. The success of the liquid phase cracking plant has been made possible only by the application of comparatively high pressures and provisions made for allowing a substantial time for the reaction to take place. It is necessary therefore, to resort to heavy construction to handle high pressures and to employ reaction chambers or soaking zones which may be dispensed with or at least can be greatly reduced in size when high temperatures are employed, such as are possible in vapor phase plants. Thus, the liquid phase plant necessarily involves more weight of equipment for a given capacity and in general involves more operating hazards. The operation of a vapor phase plant, on the other hand, being carried out at higher temperatures, makes the heating elements more subject to deterioration and the performance of the plant more dependent on accuracy of control. With proper design, however, these features can be satisfactorily handled."

1295 *Cross-Examination by Mr. Thomas.*

2644 Fall River Plant: I installed the Fall River unit
2645 sometime between 1921 and 1923. The unit was shut
2646 down when I left the New England Company in 1923
and was dismantled sometime in 1924 or '25. This
was a once-through operation. The charging stock
was always kerosene distillate of 34° Baume gravity
2647 with an endpoint of approximately 500° F. About five
or six percent of the material in the charging stock
boiled in the gasoline range. Some correction was
made for this gasoline in the charge.

2648 The gasoline yields which I gave on direct examination were based on unfinished gasoline. The finished gasoline yields would be somewhat less.

2649 At that time, all gasoline commanded a high price and we had no trouble in selling this vapor phase gasoline because it was hidden along with ninety-five percent of other material.

2650 Hall Plant at Edmonton: The plant at Edmonton, England employed a converter which was a square shaft filled with tubes made of one-inch pipe and heated at the bottom. Oil was pumped through and heated in these tubes to a temperature of 600°C. (1112°F.) or higher. The heated oil then passed into three columns called dephlegmators. Residuum was drawn from some of the dephlegmators. The uncondensed material was then compressed and pumped through a cooling coil and charged in the pressure drum where liquid and fixed gas separated, the liquid being a distillate. The gas was burned or disposed of otherwise.

William A. Hall employed me and I designed and built the Edmonton plant.

2651 1296. I was employed by Mr. Hall in this country in 1912 or '13 to work at Greenpoint, Long Island, New York. Hall was a chemical engineer who had several processes at Greenpoint; one for smelting pyrites, another for making grease, and a third, which was called the Lamplough process, purporting to make gasoline from kerosene. Hall left for Sweden and Norway and I remained to work on this apparatus
2652 for about four or five months. I made tests for Professor Chandler at Columbia University. I then took

the apparatus to London at Mr. Hall's request. Hall formed a company to finance this development. During the time I was at Greenpoint, I corresponded with Mr. Hall regarding my work. The experiments in England were conducted in consultation and collaboration with Mr. Hall's associates.

2653 The process in Edmonton was the same as the Bayonne operations except that the vapors were not permitted to go into the compressor but the liquids were first separated off and the vapors alone entered the compressor.

2654 Both the Edmonton process and the Bayonne process were essentially once-through; and I might say that the idea was that if we knew enough about cracking we could get a high conversation. The whole idea of this was to get this high conversion once through, and it never entered anybody's mind to recycle. It is very simple to look back now on the early days of cracking and say, "Why didn't you do this or that?", but there were two cycles, we thought, and one was to try to make the gasoline yield once through, and this was distinctly that type of experiment as a matter of fact.

I had charge of the operations at the Hall plant at

2655 Bayonne. Mr. Hall was informed of what was

1297 going on. The Bayonne plant was installed primarily as an experimental operation to demonstrate the process so that The Texas Company could decide whether it would continue operation on a larger scale under the Hall patents and under agreements which Mr. Hall's representatives made with

2656 The Texas Company. The expenses were paid by The Texas Company. The cost of the installation was of the order of $100,000.00. We had the resources of The Texas Company back of us in operation or attempted operation of the plant. They were very willing to give us everything that we asked for, and I would like to make this statement, that might be a little bit of digression, that Mr. Hall was a very good man to work for, and in working in the laboratory on any of his work he supplied us with whatever we asked for.

2657 At the lefthand side of the converted L on DX 623A (showing the Bayonne unit) is a small chamber wherein the burners were placed. The flame and flue

gasses passed upwards through the tubes over a bridge wall, down a shaft, through a flue passage, and up the stack. The tubes were suspended in the two vertical shafts on castings and they filled the entire shaft. The tubes were hairpin shaped tubes
2658 connected one with the other by return bends. The oil passed from the feed line into the first hairpin, then across one hairpin to the other and then jumped over from the back pass of the converter to the front pass where it repeated the course in the back pass and then out through the outlet which I have marked N on this drawing. The converters were rectangular in construction. The flame actually impinged on the bottom of the tubes in the front pass and, in many cases, the flame extended over the bridge wall. The furnace is a convection furnace. The only fur-
1298 naces that were ever used in connection with this work were convection furnaces in which the products of combustion went through the nest of
2659 tubes. The inner concentric tubes shown in Detail B are carbon catchers. Actually very little carbon was found in these tubes except when there was an accident or unsuitable stock was charged.

2660 All the operations at the Bayonne plant, save a few experiments, utilized prime or water-white kerosene as a charging stock. This water-white or prime kero-
2661 sene charging stock was redistilled and in some cases treated. The endpoint was somewhere between 500 and 550° F.

The first column marked P in DX 623-A was empty. If prime white kerosene was run, very seldom was any carbon found there. In the selected gas oil runs, carbon would plug up the coil long before any large amount of carbon was accumulated in the column.

2662 To get the conversion with selected gas oil charging stock that we obtained on kerosene would cause the tubes to foul up in a matter of a few hours.

In the operations with prime kerosene, no light distillate from the bubble tower T was ever returned
2663 to the cycle during a given operation. We attempted to run that light distillate in a second run and found it was not satisfactory. This was the same experience we had in England. It was necessary to redistill the light residue to leave off about five or ten per cent of the bottoms to make it work.

2664 The kerosene charging stock contained some
2665 1299 gasoline perhaps on the order of seven per cent.
I do not remember whether the kerosene in the charging stock was deducted from the yields but I do not believe it was.
2666 The Hall Bayonne unit was discontinued by The Texas Company probably about a year after I left.

1300 OTTO BEHIMER, Oak Park, Illinois:

Direct Examination by Mr. Thiess.

1707 I am the same Otto Behimer that has testified before in this case, about a year ago. I am the patentee named in United States patents Nos. 1,840,012 dated January the 5th, 1932 (DX 659); No. 1,883,850, dated October 18, 1932 (DX 660); and 2,027,074, dated January the 7th, 1936 (DX 661).
1711 I attended the Kansas University from 1901 until
1712 1905, receiving the Bachelor of Arts degree. After a year's intermission I completed one year's course Master's degree of Applied Sciences. In both schools I majored in the scientific courses like mathematics, chemistry and physics.
My first employment in connection with the treatment of petroleum oils was from the fall of 1912 until the latter part of 1915 with the Kansas City Testing Laboratory, which is owned by Walter M. Cross, and Roy Cross and Mr. Lyons.
1714 While I was with the Kansas City Testing Labora-
1715 tories the work I did was of a special or experimental nature. The first problem of an oil nature I had was making an analysis of asphalts in connection with some patent suit for the use of Dr. Walter Cross.
In 1913 I performed a series of bomb experiments. A bomb is a section of pipe which is sealed at one end and it has an opening so you could screw a thermometer well in and then it was drilled to put on a pressure gage. The bomb used held 1500 cc. of oil, and we charged it with 500 cc. of oil so there would be enough vapor space to hold the cracked
1716 1301 products when subjected to heat treatment. It was mildly fired or fired rather carefully and

brought up to a certain temperature and it was maintained at this temperature until the pressure came up, in most cases, to about 1500 pounds. After this pressure had been reached the flames were cut out, and the bomb was cooled to room temperature. Then
1717 the bomb was opened and the treated product was
1718 measured and analyzed. We then took samples of the oil and distilled the gasoline out of the oil, and determined the percentage that was gasoline. That would tell us the extent of cracking which had taken place in the bomb.

1722 The total time devoted to actual experimenting in this oil work at the Kansas City Laboratory was from six months to a year. There were two different periods, one period in 1913 we worked quite a while and then there was another period in 1915.

1724 In 1915 after we had completed one series of experiments on the bombs, Dr. Walter Cross had an appointment with R. C. Holmes and G. W. Gray of The Texas Company to witness one of the demonstrations, and he asked me to come to the laboratory and run the experiment for them because I had been doing most of their experimental work on cracking. Later when Dr. Cross could not continue his cracking work, I wrote Dr. Gray asking if I could get employment, and Dr. Gray sent back an application blank to be filled out and I filled the blank out and returned
1725 it. I received word from Dr. Gray and was instructed to report to the Port Arthur Works, to Mr. F. C. Smith, who was the superintendent of the Port
1302 Arthur works. I reported at Port Arthur on October 25, 1915.

1726 At that time the Burton process was the only commercial process that I knew of in existence. I also made a search of all the cracking literature I could find.

1727 At the time I entered its employ The Texas Com-
1728 pany was making its gasoline commercially by the use of atmospheric distillation; what we call straight run gasoline. The only place that they were producing gasoline was merely in the coke stills and possibly in the last still of the lubricating still. After going there, I went over the coke stills and determined where the cracking was and took samples every two hours from beginning to end, and found out they

were cracking. The cracking they were getting in the coke still was in the range of 5% or thereabouts.

1729 My f st assignment at Port Arthur was to obtain different grades of oil in the plant, that is of The Texas Company operations, and run them in bombs similar to the bomb experiments that I had performed in the Kansas City testing laboratory, excepting the

1730 bomb was made much larger, it would hold about 3 gallons, the charge to the bomb was one gallon. The purpose of the tests was to determine how much gasoline these different grades of oil would make and what was the nature of the carbon deposit.

1731 In the next operation I conducted, I mounted an air condenser on top of the bomb and I made an attempt to distill to find out the character of the product, and also something about at what pressure you could distill. I found we couldn't get the gasoline out of the still.

1732 The gasoline we obtained as a result of the distillation of the synthetic crude gave me a line on the yield of gasoline that could be obtained. It gave me a line on the carbon condition. It gave me a line on the relative amount that you could get from different grades of oil.

1733 1303 Then we made another series of tests in which we tried to find out the effect of catalyzers and we ran them about all the different things we could find to make aluminum chloride.

1734 The first experiments on these bombs at The Texas Company, were started in the early part of November, 1915, and they were continued with this furnace until about April or May, 1916. After that, in order to get the rate of the decomposition which we were very much interested in, we made a gas furnace, so we could fire more carefully, and we determined the time

1735 that it took to bring the bomb up to 1500 pounds pressure at different temperatures, in order to get a line on the rate of cracking. That was completed, I would say, about August, 1916.

I was next called into a conference on a Redwood still that was to be built according to the patent description. This was immediately drawn up by the engineering department, and they started building it in December of 1915, and we started operating the

1736 first still in January of the next year, 1916.

1737 DX 662 is tracing X1123, dated December 4, 1915, and shows the Dewar and Redwood apparatus designed and constructed at that time at the Port Arthur works.

1738 Using DX 662 and describing the process or operation conducted in this apparatus, we had a small charging pump which is not shown here, with which we charged the still until it was about half full of oil, which was approximately 23 gallons. After the still A was charged, the fires were lit and the temperature was brought up, gradually at first, until the heat began to show up in the air condenser or the still head B it is marked here; and as soon as it began to show temperature there, the valve was closed on the gas line and the receiving line. The furnace gases would pass up and around and over the still, i. e. all around the top, bottom, and sides.

The condenser coil and water box is marked C and the receiving drum is marked D. The furnace is
1740 1304 marked E. The gas line outlet is marked F; the liquid or distillate draw-off line is marked G; the charging line is H; the draw-off line is I; the thermometer well in the rear of the still is J; the thermometer well in the top of the air condenser or still head is K; the oil level gauge glass is L; the pressure gauge is M, at the top of the still head or air condenser is the safety valve N.

1742 After the still was tested, the still was charged approximately half full of oil by means of a pump not shown, which is connected with the charging line H. After completing the charging, the fire was started and the still was carefully heated until the temperature began to show in the still head marked B. Then the valve F on the gas line from receiving drum was closed, and the valve on the distillate outlet G was closed, and the firing was continued until the pressure was brought up to the desired pressure, which varied from 80 to slightly above 100 pounds in the various operations.

Then the firing was controlled so as to obtain a given gravity product which was controlled by the temperature or regulated by the temperature shown in the thermometer well marked K; and as the distillate came over it was measured at intervals, de-
1743 pending upon the rate of formation. About 40 to 70

per cent of distillate was taken over of about 52 to 56 gravity. Then the fires were cut and the still was allowed to cool and emptied out and the residual oils were measured, drawn off and measured, and
1743 1305 then we removed the head from the rear of the still and inspected the carbon and cleaned the still to get ready for another run.

1744 The 375 to 350 end point gasoline obtained from the pressure distillate ran as high as from 50 to 75 per cent. There were a few runs that we couldn't get the pressure and our distillate was a little heavier than we would have liked to have it to extend the run. This apparatus was designed for 400 pounds but we could not operate at 400 pounds. At first it did not look like we could operate at 100 pounds; we dropped back to 80. The chief difficulty was the leakage, the manway and the fittings. They would
1745 not stand the pressure. The chief reason was the manway.

1746 We made about ten or eleven runs on the equipment as it is shown here from the middle of January, on to the middle or a little later in February, 1916. The first stock used was a light gas oil and at 80 pounds pressure we couldn't get a cracking rate that was suitable, and so we took off 30, 40 or 50 per cent of the light ends and charged the residue back into the still. That second stock we cracked and it ran very well.

1747 The product obtained from running this reduced gas oil, as compared with the product from the bombs, had a very high heat reaction and a very high olefin test.

1748 The flames not only played over the liquid portion of the still but they played over the vapor space of the still. Dr. Gray suggested that we drop this
1748 1306 brick work or the top of the furnace down so that it would cover the upper portion of the still, so that we would obtain the conditions that were practically identical with the heating conditions in the Burton still.

DX 663 is a blueprint from tracing No. Y1568, and shows the changes and modifications on the Dewar & Redwood still that were made and as the equipment was installed and operated.

1749 The major modification was the dropping of the

roof or top of the furnace down so it would cover the upper half of the still. That was to cut off the heating of the vapor pressure of the still and to make the equipment conform more nearly to the Burton type still. Also, the air condenser was inverted,
1750 set up straight instead of horizontal, in the hopes that it would give a little better separation. The receiving drum which was welded to the water box in the former setup was entirely removed or was removed and connected by a valve line to the cooling coil so that we could control the pressure from the condenser coil outlet instead of from the valve on the receiving drum. The apparatus was modified to effect the changes which I have described prior to run 12, which was made on February 25, 1916.

1751 The drawing, DX 663, was made from the apparatus after the operation was completed. The date of this drawing is September 9, 1916.

The Dewar and Redwood apparatus exemplified in DX's 662 and 663 was operated only as a batch
1752 operation. The apparatus shown on DX 663 was also operated as semi-batch where we charged more oil into the still during operation but did not draw
1752 1307 residuum. In a batch operation, your charge to the still is all put in at the start, you run off the distillate you want, you empty up the still
1753 and you take your yield. A semi-batch is where you charge the still and in order to increase the capacity you charge during the operation but you do not draw tar. You take nothing out of the system except the product that you want. That is, of course, you might say you want tar but I am speaking of tar as the undesirable product, residuum. A continuous operation is where you get a still under equilibrium and you have everything functioning. You have your distillate running continuously, all your vapors coming to your vapor lines. It is a definite concentration. You have your charge going to your still continuously and you have your tar being drawn continuously. That is, you get a constant condition. We will say if there is a liquid, like a liquid feeding, you will have a constant oil level and you get an equilibrium where everything is balanced. You are making distillate at a certain rate, you are making tar at a certain rate, you are charging at a

certain rate, and you have got constant temperature conditions.

1754 The operation of DX 663 as semi-batch was just the same as the one previously described for the Dewar and Redwood apparatus excepting the pump was started in order to maintain a constant oil level in the still during the operation of the process. We made several runs as batch and then the remainder of the runs, I think were all semi-batch. All these runs were completed near the first of August, 1916.

1755 The results of these semi-batch operations were in a way rather surprising. The product had a
1755 1308 very much lower heat reduction and a very much lower olefin test.

1756 "Q. Now will you continue with your answer as to the results that you obtained in operating this apparatus?"

"A. We obtained, I would say, a good product, and we could obtain a fairly good yield but the eyesore in the part was the carbon that collected on the bottom of the still. It seemed like the carbon was so great that it would be hopeless to ever try to make a continuous process, or it would have been to me, to have even thought of trying to make a continuous process."

As the operation proceeded, there appeared to accumulate in the air condenser a material that was a kerosene fraction.

1757 This kerosene distillate that thus accumulated in the still was really the thing that cinched my opinion
1758 that there is only one way to make a continuous cracking process, because in the Burton still they didn't run a product of constant gravity.

In a continuous process you need to run a constant product. Now the thing that I figured that you had to do, you had to remove that kerosene product out of the still and take it back some place where you could heat it hard enough to crack it and prevent its accumulation. That is the point that determined and settled this coil and drum, as far as I am concerned,—this internal heating scheme.

1761 After I noticed this kerosene fraction in the operation of this still, my conception was to have a continuous cracking process in which the vapors would be maintained constant in your air condenser part

so they would give you a constant gravity product or cracked distillate, and to return this undesirable product, kerosene, back with the charge through a heating equipment where I could subject it to a
1309 higher temperature and wear it out, which was necessary to maintain this constant vapor condition that would give us this product and have some
1762 place where you could separate the high coking material out of the system so that it wouldn't contaminate it, carbonize it; so it was a constant charge, constant distillate and a constant return of the reflux to the heating coil. The cracking reaction goes in two ways: it goes to give you a gasoline and it goes to give you a product which is similar to asphalt which is very undesirable and high coking. I got this idea about February 25th, 1916. I made a sketch in trying to make something out of the Redwood apparatus, in an effort to see if I couldn't improve it so they could make a continuous process out of the Redwood.

1763 DX 664 shows an improvement or another modification of the Redwood equipment in order to make a continuous process out of it to overcome the accumu-
1766 lation of the kerosene fractions in the air condenser so that we could run a constant gravity distillate.

1763-4 I made this drawing, DX 664, some time after February 25th, 1916, the date of the first run with
1765 the Burton type Dewar-Redwood apparatus. This modification of the Dewar and Redwood still, as shown on the sketch DX 664, was never operated as shown here.

1766 DX 664 shows a drum at the right-hand side with a vapor line in the top of the still to near the top of the drum, and a liquid line or oil line from the bottom part of the still to near the bottom of the drum. The still is connected to a tar line at the bottom so you could draw off the undesirable cracked heavy residuum. The top of the drum is connected to an air condenser where the heavy vapors can be
1310 dropped out and the light desirable vapors, gasoline like vapors, taken off at the top, which is marked "To condenser box". The kerosene fraction which we wished to break down or wear out is pumped down from the bottom of the air condenser and returns to the front of the still where it meets

1767 the charge, which is shown "To pump" at the left-hand side. This is merely a preliminary drawing made at some time to try to improve the Redwood apparatus and overcome this kerosene trouble. For the oil level we picked the middle of the drum because we didn't know until we experimented where we would want it. Of the two lines marked "6-inch lines" leading from the still to the tank, the top
1768 line is a vapor line so that the vapors could equalize from the still to the drum, and the bottom line is so the oil could equalize from the still to the drum. The longhand description at the bottom of the drawing merely specifies the condenser box and the receiving chamber to go under pressure. That means it is to be carried under pressure in the system. The relief valve for pump, that was merely a safety precaution, I might say, and also to regulate the charge better. The last line reads "Only lower half of still
1769 exposed to the furnace." The significance of "Apparatus for 400 pounds pressure" at the right-hand top of this sketch is that I wanted 400 pounds pressure capacity and a faster rate of cracking.

"Q. Now, you said you made this sketch (DX-664) some time after February 25, 1916. Can you fix that a little closer?

"A. The only thing that bothers me in this sketch, it is a little better sketch than I usually draw, and after thinking this over I don't remember this idea I had in mind. It might be that this sketch was made later when we did build equipment similar to this. That is, it might be near that time."

1770 1311 "Mr. Thomas: When was that?

The Witness: Well, that would have been—we built the—the equipment was operated in, let's see, February, I think.

Mr. Thomas: What year?

The Witness: I think it was February, 1917. Then I don't know when our blueprints were made up. This would have been before any blueprints would have been made of the equipment. So as far as this sketch goes it was either made, we will say, shortly after or it was made just before we drew up the rough drawing for that modified Redwood apparatus.

Mr. Thomas: In February, 1917?

1770 The Witness: Yes.

Mr. Thiess: Wait.

Mr. Thomas: I am just trying to get the date straight.

Mr. Thiess: I am trying to keep this straight.

1771 The Witness: No, I will tell you the first drawing was made in November on the coil and drum, and this was either made after the experiment, shortly after the experiment date—

Mr. Thiess: Q. What date was that?

A. That would be February 25, 1916, or it was made shortly before they made the drawing for the modified Redwood apparatus, in which we utilized this return but we didn't put the drum on.

Q. What date was that?

A. That would have been, I would say, about November, somewhere in there, of the same year.

Q. Of what year?

A. 1916.

Q. Now, did you do anything further in the way of devising an apparatus to incorporate this idea of yours, other than that shown in this drawing, Exhibit 664?

A. What was that now?

Mr. Thiess: Will you read it?

(The question was read.)

1771 1312 "A. Yes, there was an apparatus built, designed and built and operated, similar to that with the exception that the drum was not used.

1772 Q. When did you first conceive of that?

A. Well, I don't—you have asked, particularly, the principle. I conceived it back, I figure that it was near February 25th, but when I made the drawing or when I figured that identical apparatus I can't say. It was before it was designed.

Q. Now did you ever discuss this idea of the returning of the reflux, as indicated in this sketch, with anybody?

A. I know I had this idea a considerable time before I disclosed it to anyone, and as I remember the first disclosure that I made was to William Donaldson, who had been sent by Mr. Holmes to look after the patent work at the Port Arthur works, and I have established that not from memory but by the fact

that the first trip that William Donaldson came to
1773 Port Arthur was July, I think the later part of July.

Q. Of what year?

A. With my memory I establish that as the date, that he is the first party that I ever disclosed the idea to.

Q. What year was that?

A. That was in July, 1916, the latter part of July, I think.

Q. Who was this Mr. Donaldson?

A. He was a young graduate, I think, from the law school, and I think he had worked for the Texas Company during the summers prior to this time. Mr. Holmes selected him to take care of the patent work immediately under his direction.

Q. Where, at Port Arthur?

A. At the Port Arthur works.

Q. Can you now state the substance of your conversation with Mr. Donaldson at the time that you disclosed this process to him?

1773 1313 "A. The chief thing, the thing that I emphasized, was that I thought I knew how to make gasoline, and any continuous process that would ever distill, a distillation process, would have to use
1774 it, and that was the return of the reflux. I think I disclosed enough to him that he knew that it was to draw off distillate and draw off tar, and a continuous return, a constant vapor composition going to the air condenser so that you could run a constant product.

Mr. Hall: Now, if your Honor please, I move that the answer be stricken out for the reason that it is just a statement of a conclusion. It seems to me the witness ought to state actually what he said to Mr. Donaldson, or if he can't remember what he said, to give the conversation as nearly as he can, but all he has given here is—

The Court: Yes. Don't you think that is a good objection?

1775 Mr. Thiess: Q. Will you state in substance what you told Mr. Donaldson at this meeting when you disclosed this matter to him?

A. I just can't tell you exactly, if you want the exact words, but if you want to know whether I disclosed it to him I can answer that.

Q. Can't you tell what you told him in substance?
A. No.

Mr. Reichmann: As nearly as he can, I submit, your Honor.

The Court: As nearly as he can.

Mr. Reichmann: If he can't remember exactly he can give the substance of the language that he used.

The Witness: I can't remember back that far.

Mr. Reichmann: That is the way that should be brought out.

Mr. Thiess: Q. We are not asking you to give the exact language, Mr. Behimer. Just tell in substance what you told Mr. Donaldson.

1776 1314 "A. Isn't that what I told you? I told you that I conveyed to him the idea that I wanted a continuous distillation process.

Mr. Hall: That is a conclusion.

The Court: Yes, it is. That will have to be stricken.

The Court: Well, Mr. Behimer, I don't know how far I want to go into the explanation myself. You cannot say that you disclosed things to him. You have got to tell the substance of what you said, not the language that you used at the particular time but
1777 the substance of your statement.

1778 A. I told Mr. Donaldson that I thought I had a process that everybody would have to use, a continuous distillation process, of which the chief feature was to return the reflux to the heating coil, and that was to run a constant gravity distillate product and to draw the residue or the undesirable products continuously from the oil.

Q. Now, have you stated when you told Mr. Donaldson this?

A. It was the latter part of July."

1779 The next party I talked to was Mr. R. C. Holmes. We had started another equipment, which merely consisted of a heating coil and a condenser coil. We heated the oil in the coil and it dropped right into a
1779 water condenser coil and was cooled immediately
1780 down. Mr. Pond and I had just started the equipment when Mr. Holmes and Mr. Manley happened to come in where we were operating. That was about August 12th, 1916. The first discussion we had was
1781 about the operation of the coil and concerning the drum. I don't know who brought up the drum,

whether Mr. Holmes or myself. We were considering this as a process where you make synthetic crude. This discussion was on the drum. You would run the oil out into a drum and the heated oil would crack from its own heat.

1315 After we discussed this phase of the proposition I told him that I thought there was only one way to make gasolin. and that was a continuous dis-
1782 tillation process. I pointed out the different features. We had the apparatus right there, and we would have a still at the end of the heating coil, and we would bring the vapors up over into an air condenser, and the back trap would be returned to the heating coil and the tar would be drawn from the bottom of the vertical still or vertical drum that we were discussing.

1783 "Q. Now, you have stated that you also talked about this operation to Mr. Harris Smith. Do you remember when you talked to Mr. Smith about this?

A. I don't remember from my own memory exactly but I have records that Mr. Smith had. But I do know this, it was during the time that we were operating coil 8.

Q. About when was that?

A. That would have either been August or September.

Q. Of what year?

A. Of 1916. He was sent or came to the laboratory and told me he was sent by the engineering department or the draftsman, chief draftsman—I forget which—to make a drawing of the equipment as it was standing, as it existed there at the time.

1784 Q. What did you tell him?

A. I told him that I was not interested in that, that I thought I had a process of making gasoline and I wanted him to draw up something we needed.

Q. What did you tell him to draw up?

A. I told him to draw up a coil and drum and to return the reflux. I told him I wanted to return the reflux back with the charge, and I wanted to draw the tar, and I wanted a continuous distillation process where everything would be maintained constant, but the joker in it was I didn't have anything to
1316 pump this hot oil and I wanted somebody to secure a device to do this work.

1785 Q. So we will have a continuity of the story, will you again start in and tell us what you told Mr. Smith about this process.

A. I told him that I had an idea of a continuous cracking process in which you took off the distillate continuously and draw the residue continuously and 1786 returned the reflux fraction from the bottom of the air condenser to the coil but I did not at that time know of any device that I thought would do the work on account of the high temperature.

Mr. Thiess: Q. What device are you referring to?

A. The pump to return the hot reflux back to the inlet of the heating coil.

Mr. Thiess: Q. And what was the discussion that you had with Mr. Smith about that?

A. Mr. Smith said in substance that he had in his work around the plant, was familiar with some kind 1787 of an injector that was being used, and he suggested that as a device for returning the reflux.

Q. And what did you tell him with respect to why you would have difficulties with a pump in returning this reflux?

A. Well, the ordinary steam driven plunger pump, they would handle cold oils at ordinary temperatures very readily because they had packings and they had pistons that would stand those temperatures without scoring and had packings that would not deteriorate, but when you went above 500 or 600 degrees temperature there were no packings that were known that would hold, that is would stand up against that temperature. And also the pistons would score and at that time I did not know of any piston and things that would work under those conditions, and I know of no packings except possibly copper that would work at that time. And I figured that it would be an impossible thing to use an ordinary pump.

Q. And what was your reaction to the suggestions that Mr. Smith made with respect to the injector feed?

1787 1317 "A. Well, I knew a little about injectors 1788 because they had used them on the farms in threshing machines and things like that, and I was very much taken with the idea. I did not know that you could take liquid, the only kind of an injector I had ever seen was a steam type to lift water into

steam boilers, but if it was possible I thought it was ideal because it was something that we knew how to put together so it would not leak and would not be affected by the temperature."

1788 After thinking it over, I contacted Mr. Witherup in the machine shop and later on, Mr. Witherup built one and tried it in the shop and then he built several and tried them out with water at the machine shop.

1789 1318 DX 665 was drawn up by Clarke & Abbey, August 17th, 1916, and it is a diagrammatic lay-out of the heating coil in the experiment that we called coil 8. My conversation with Mr. Smith was directly after this drawing was made.

1790 Original coil experiment 8 was an experiment which consisted, or an apparatus which consisted, of a heat-
1791 ing coil mounted in a furnace and a condensor coil mounted or installed in a water cooling box, and that was the essential part of it. Of course, we had the necessary pumps and tankage, gas tanks, gages and thermometers.

DX 666 is a drawing that was made by Harris A. Smith and is dated 9/18/16, and shows the equipment that we have been talking about which we called experiment coil 8. This is the coil experiment I described earlier in my testimony. This is the apparatus and operation that I referred to in my testimony when I talked to Mr. Holmes, on August 12, 1916.

1792 The substance of my conversation with Mr. Holmes at that time was: After discussing the process, this particular equipment of DX 666, I told him that I thought there was only one way to make gasoline, or
1793 something to that effect, and a distilling process in which you returned the heavy vapors from your air condenser back to the coil inlet so that you could pass it through the coil with the charge and wear it out or break it down. And I told him it was to be a continuous process in which you took off a constant naphtha distillate and withdrew the residuum or the carbon making oil from the bottom of the drum.

1749 1319 I also talked to Mr. Detwiler about this process of mine, shortly after he was put in charge of the research work at the Port Arthur works which was in the early part of August of 1916.

I told him I thought I had a process to make gasoline and told him that I wanted to return the reflux back to the coil so it could be subjected to a higher
1795 temperature and worn out, broken down, and it was to be a continuous process in which you took the constant product, naphtha distillate, and your constant charge, and constantly withdrew your residuum or the carbon forming residuum oils formed in the process.

Mr. Smith made a drawing for me in the first of November 1916. He brought the drawing over for
1796 me to look it over; he had a rather large device for a jet pump, it looked to me more like a steam condenser than it did a jet pump; and then he had taken plenty of room to make his drawing and I wanted it more compact so it would cut off the radiation
1795-6 1320 losses, I did not want any long lines leading back and forth in the apparatus, so it would be cooling, it would not entail the loss of heat, and I made certain suggestions to Mr. Smith and he made the corrections and notations on the drawing.

DX's 667 and 667-a are photostats of blueprint 9063 of that drawing. Mr. William Donaldson, the
1797-8 patent attorney, took this blueprint from my files, a considerable time later, in '19 or '20 or '21. It had been in my files all the time since I first received it until Mr. Donaldson took it from my files.

1799 At the right-hand side of DX 667, I have marked the jet A. This is the part that did not look to me much like a jet; we had some discussion about it and Smith made a notation on the coil near the inlet of the heating coil, to show about the position that it should be placed, which is marked B. The air condenser and the connection line he drew in the sketch showing it over closer to the coil so that there would not be so much radiation loss and loss of heat. The air condenser C was changed over to the air condenser D.

1800 1321 DX 667-A shows that this drawing was com-
1801 pleted on November the 6th, 1916. The date, November 6th, is taken from what I find on the blueprint, but I remember it was about that time.

1802 The apparatus and process of DX 667 is as follows: Beginning at the charging line the oil from the pumps, not shown, flows through the charging

line marked 1 to the jet pump marked A; thence in mixture with the reflux coming from air condenser C flows through the U-bend marked 2; thence to the heating coil inlet marked 3; thence through the coil to the outlet marked 4; thence to the drum where the liquid oils collect and the vapors and gases flow up from the top of the drum through the goose neck marked 5; and thence to the air condenser marked 6, where the gasoline or naphtha distillate is separated from the reflux—the naphtha distillate passing over the top of the air condenser to a condenser coil, not shown; thence to receiving drum and tankage. The reflux collecting in the bottom part of the air condenser is picked up by the charge, by the jet A, where that mixture flows back to the heating coil and the same from there on as previously described.

1803 The oil or the residual oil and the oil collecting in the drum is drawn through the tar line 6 so as to maintain a constant oil level in the drum. I determined that oil level by means of a gage glass, a Nathan reflex gage glass 7.

1804 1322 There are fourteen tubes and these tubes were connected by return bends which were made in the blacksmith shop by taking a billet of steel and hammer-welding it into a rectangular block of steel about six inches square and about 15 inches long. These blocks were drilled out in the machine shop so as to have an opening through the center; the one side was faced, or first drilled with two 3-inch openings spaced about approximately eight inches apart from center to center; and the side was faced, and the face side was fitted with stud bolts spaced so as to correspond with the holes in the flange that is screwed onto the tubes, so that one of these could be picked up and the stud bolts pushed through the corresponding holes in the flange, and the gasket inserted between the stud bolts so as to seal them.

1805 When Mr. Smith laid out this drawing and I told him how to make it and the process I expected to operate, I told him that I expected to use about 500 pounds pressure and the temperature would be variable from about 800 to 1000 F. That temperature would be measured in the coil outlet.

1806 After my conversation with Mr. Smith regarding the corrections in the drawing, the drawing of this coil and drum apparatus was turned over to a draftsman, I presume, that was more familiar with construction work, to make a construction drawing for
1807 building the equipment. The draftsman was Mr. B. R. Schneider. The drawing that Mr. Smith had made was turned over to Mr. Schneider.

1807 1323 DX 668 is blueprint number 10316 of tracing number Y-1703. It is a drawing that was in my file and on which I made some pencil changes. They
1808 had only two tubes in the bottom coil, and I marked on the blueprint with red pencil the position of two more tubes, brought the tubes from the top down to the bottom row, and it is so shown for both views, for both end views. I made the changes so as to have four tubes in the bottom row so as to get, or
1809 at least thinking it would give more even and better heating. I got that blueprint shortly after the date shown on it as being made, i.e., December 7, 1916. I have no way of fixing it except I received the blueprints shortly after they were made up.

1810 DX 669 is original drawing Y-1703, dated 12-7-16 and revised 1-29-17. The fact that there is no marking of a revised date on the blueprint, DX 668, helps me to fix the date when I received DX 668, as being before the date of January 29, 1917.

1813 The longhand writing on the reverse side of DX 668 is in my own handwriting, and it is some data concerning the volume and capacities of the drum and coil and the air condenser and some data concerning the dimensions of the nickel tube; also some data concerning the condenser coil as to length and diameter. I put those notations on that blueprint shortly after I received it. It was before they really started constructing. It was sometime between 12-7-16 and probably January, 1917.

1816 After the completion of the drawing DX 669, the engineering department went to work to obtain the material that had to be ordered, and orders were sent out for dished heads, valves, and fittings and different necessary parts that were not in stock or
1817 available at the plant. These dished heads were
1324 ordered in February sometime and received during March. The apparatus or the parts,

and the material to build this apparatus was finally
1818 obtained and assembled between January 29, 1917
1819 and May the 25th, 1917. When this equipment was finally constructed, it compared with the working drawing, DX 668, as follows: First, two of the upper tubes were brought down to the bottom of the coil so as to make four tubes on the bottom row of coils. The furnace was changed so that the arch was extended completely the full length of the furnace, and the checker was extended the full length; the baffles instead of being mounted vertically were
1820 mounted horizontally. The baffles were mounted on top of the coils. The tar line instead of being a 4-inch pipe was a 2-inch pipe, and was welded directly to the lower part of the drum. The vapor line extending from the top of the drum, instead of being riveted was welded.

1821 DX 668 only shows the parts that were needed to make or to do the shop work of constructing it. The pumps, tanks and necessary piping, manifolds, things like that, are not shown on there. I made a list of tanks for the operation and turned it over to Mr. Detwiler, and he took it up with the Houston office and finally they decided that they would loan us some tanks.

1822 The jet pump that was made up by Mr. Witherup in the machine shop was incorporated in the equipment as constructed in the reflux or back trap line at the junction with the charging line.

1823 DX 671 is a drawing of this jet pump and was made by E. T. Earnest. The notation "Jet pump
No. 1 made by Mr. Witherup" on the drawing
1823 1325 is my handwriting. I believe that "Used in
Exp. 8" is my handwriting. I think that "No. 1" is my handwriting, and the rest of it, I think, belongs to Mr. Earnest. This drawing was made just after some tests were made on the jet under the shed near this equipment on May 8th, 1917, between that date and May 25, 1917.

1825 DX 672 is a preliminary test made on the jet pump
1826 as shown on DX 671. I was there when the tests were being made. I know about these particular tests that were put down by Mr. Earnest. I laid
1831 out these tests as to how they were to be made.

We mounted the jet pump over the barrel and dropped a line, a two-inch line, down into the barrel so it would dip under the oil. Then the inlet part of the jet was connected to two Marsh pumps which fed
1832 a charge. Then we gauged the charge and deducted the charge from the total, and we had our pickup.
1833 We didn't know what the capacity of the equipment would be when we started, but we put it there and it would lift two or three feet. It worked very nicely. We worked it several different ways to see how it operated. It was just a preliminary test before we hooked it on the equipment.
1836 After the equipment was ready to start operating, I told Earnest that I wanted him to make drawings of the equipment as it was constructed, and also to make any changes that we might make during the runs so we would know exactly what kind of equipment we had for each run.
1836 1326 The drawings, DX's 673-A and 673-B were made up by Mr. E. T. Earnest during the time that we were operating the equipment between runs. He took these dimensions directly off of the equipment as it was set up.
1837 DX 673-A shows the important parts of the apparatus. You see the air condenser is cut off at the vapor line and no part of the equipment is shown beyond the outlet of the air condenser. The charge pump, the condenser coil, water box, receiving drums
1838 and the gas tanks and the distillate tank are not shown here. The tar line is also broken beyond the valve at the bottom part of the drum. The water box and the tar coil are not shown, nor is the tar tank and the connections.
1841 DX 673-A shows the heating coil mounted in the furnace and a drum mounted outside the furnace, and an air condenser connected by a vapor line to the top of the drum. The coil inlet shows a jet pump and the charging line. The jet pump has just been shown and it connects to the inlet tube of the pre-heating coil. The pre-heating coil consists of 14 tubes of 3-inch inside diameter nickel steel pipe. These tubes were approximately 16-6/10 feet long and they were connected by means of these forged headers which were bolted up onto the coils with

copper gaskets so that the oil entering the inlet of the coil could flow continuously down through the total coil from the inlet to the outlet. From the outlet of the coil, the oil passed through a 3-inch valve
1842 to the drum, at a point slightly below the center line.

The drum was a little over six feet long and
1842 1327 two feet in diameter. The circular device shown at the lower part of the drum is a 16-inch manway that was put on so that it could be opened up for inspection and cleaning, if necessary. The heated oil from the coil passing into the drum, the portion that is in the liquid phase, is maintained
1843 a constant oil level. That level in this case was approximately carried at the middle of the drum.

The vapors coming from the coil as well as the vapors arising from the oil that was decomposing or vaporizing in the drum passed through the goose-neck over into the condenser or to the air condenser, where the heavier fractions were condensed and the lighter fractions passed through the vapor line to the condenser coil, not shown in this, to the receiver drum and thence to tankage. The backtrap or condensate—also known as reflux—flowed down through the back-trap line, through a U-bend, to the bottom part of the jet pump. The charge coming through the jet picked up the back-trap, thereby giving a uniform mixture of back-trap and charge to the inlet of the heating coil. The oil cooling in the drum was drawn through the tar line to the tar coil, cooling coil, and thence to tankage. None of the residuum that was withdrawn from the tank was ever
1844 returned to the system. That was the purpose, to remove these oils of high carbon-forming properties. This drum was to operate or collect the heavy oils, the high carbon-forming oils, together with some other oils, and that was to be drawn off so as to avoid the carbon troubles.

1844 1328 The elevation of my condenser over the inlet to my first coil was approximately five feet.

1845 The level of the oil in the tank was maintained by the tar draw-off. The purpose of the goose-neck in the vapor line from the drum to the partial condenser together with the U-bend was to design this apparatus so that it either had to work or puke.

If the oil was flowing through the coil and you were getting the proper temperature gradient, you would know from your temperature gradient that the oil was flowing through at a high temperature. If it was flowing through at a high temperature and it was maintaining the drum at a high temperature, at which vapors would be generated, there would always be
1846 a flow of vapors through this way, from the top of the drum to the air condenser. If the jet didn't work and the back-trap collected in the bottom of the air condenser kept building up until finally it got up to the top. As long as this temperature gradient exists and there is a flow of vapors up through the vapor line there is no possibility of this oil returning back to the drum. If it did return you would have to reverse the flow of your system. If you did that your temperature gradient was shot.

The bottom U-bend was made so that no vapors could go back in a reverse direction.

1847 So long as your temperature gradient is working this back-trap must go through or in time it is going to puke and it will contaminate your distillate and it will be off-color and you know it is not operating—so it either has to work or puke, one or the other, either operate or puke. I never at any
1847 1329 time in any operation saw the apparatus reverse itself and puke.

We never took any temperature at the jet pump because of the difficulty of installing a thermometer. The temperature of the line leading to it was hot, and also when we took the samples from that line
1848 the oil was hot and I have no recollection of drawing off when it wasn't hot or when this line wasn't hot, which showed that hot oil was coming down through the U-bend and returning to the jet. I touched the jet while it was operating. The jet was always hot and that indicated that the back-trap was returning to the coil.

1849 Looking at the left-hand drawing, DX 673-B, there is a thermometer well installed at the inlet of coil 2 or tube 2. There is another thermometer installed at the outlet of coil 3. There is another thermometer installed at the inlet—I should say tube 6. It is always tube instead of coil in that case—tube 6.

There is another thermometer installed at the inlet of tube 10, another thermometer installed at the inlet of tube 14, which is the last tube of the coil. Looking at Exhibit 673-A there is a thermometer well installed near the bottom, about 12 inches from the bottom of the drum, to record the oil temperature, and so indicated on the drawing. There is a recording thermometer installed about 8 inches or 10 inches from the top of the air condenser. This was, as I remember, a Brown recording instrument. That is
1850 also indicated on the drawing. That is all the vapor and oil temperatures.

The pyrometer No. 1 was installed immediately between the bottom or immediately above the bottom row of tubes about one foot from the front of the furnace. Pyrometer No. 2 was installed between the brick arch and the bottom row of tubes
1330 about a foot from the front of the furnace.

Pyrometer No. 3 was installed in the middle
1851 of the furnace between the arch and the lower row of tubes. Pyrometer No. 4 was installed about a foot from the rear wall between the lower row of tubes and the brick arch. Pyrometer No. 5 was installed about a foot from the rear wall between the lower row of tubes and the row of tubes immediately above that. The pressure was maintained by means of a valve in the outlet of the condenser coil. That is the condenser coil that is not indicated on the drawing.

A Bristow recording pressure gauge and an Ashcroft gauge, indicating type, was installed at the outlet of tube 2 shown on DX 673-B. An indicating gauge was shown on the outlet of tube 7, an Ashcroft indicating gauge shown on DX 673-B.

1852 An Ashcroft indicating gauge is shown at the top of the drum on DX 673-A. I believe that is all the pressure gauges that were installed except on the receiving drum at the end of the condenser coil, and that was an Ashcroft gauge that was installed at the top of that. I think that is all the gauges that I remember now that were installed on the equipment.

We had an Ashcroft pressure gauge at the Marsh charging pumps. It was probably installed on the manifold line.

1853 These dished heads that I have referred to are incorporated in this chamber that is shown on this drawing DX 673-A. This apparatus was supposed to stand four to five hundred pounds pressure. The drum was insulated; the vapor line up to the top of the goose-neck was insulated; the back-trap line was insulated, and we tried to insulate the headers and the manway, but it caused us trouble with leak-
1331 age, and they catch fire underneath, and we had to abandon that. There was no insulation on the air condenser. We wanted all the cooling we could get there.

1854 After this equipment had been erected, I operated it. We operated it from May 25th on until the first of August or September, 1917. I was in charge of
1855 this operation. I laid out a plan for the whole series of experiments at first. It was to be run through variable pressures from, say, 200 pounds up to 500 pounds, and it was also to take each specific pressure and run it through a variation of temperatures, that is temperatures from, say, 800 to 950 or 1000 degrees temperature.

1855 1332 The purpose was to find out the effect of these different pressures and temperatures upon the product that was formed and carbon deposits.

1856 I outlined the operation for each run and about what pressure and temperature it was to carry.

Generally, I would give the still foreman the pressure. That would be one instruction, to carry a definite pressure. We would carry a definite temperature on the coil. That is the inlet in this case of the tube 14. Then the instruction would be to run a certain percentage of product of a certain gravity; that is, that would determine the amount of tar, and you would charge so as to obtain this percentage.

These instructions, of course, were not always car-
1857 ried out. There was the trouble, but they tried to do it.

I gave them instructions with respect to the recordation of data. A form was made and they were directed to record the strokes of the pump, the pressures on all parts of the equipment where pressure gauges were provided, all the temperature points on the oil and vapors, and also the furnace temperatures.

They were to report or to take the gauges of the distillate periodically, say, every thirty minutes.

1861 The practice at The Texas Company relative to experimental work was first to have some experiment in view and get our plans and then take it up with the engineering department, to get drawings made, and then order in the material and construct the equipment. Then after it was constructed to have a specific plan of experimenting, and then to plan the data that you wanted to take in the operation, that is to make out run sheets or whatever

1861 1333 was necessary to record the vital information. Then after the operators had completed the operations and recorded their readings and information the results were compiled and tabulated or cal-

1862 culated and made into a complete report and recorded.

1863 In an operation on a cracking process, items that were usually recorded were the pump operation as to pressure and amount of charge, the pressures on the different parts of the equipment, the temperatures on the different parts of the equipment, the gravities of the products that were being formed, the samples that were taken for laboratory tests were taken at intervals, the fuel was usually measured periodically, the gas was usually measured at these intervals, and then at the end of the run they always took a combined sample, they called it, which was taken from the tanks so it would be representative of the total product. The practice I have outlined was followed in gathering the data on the runs that I made on the apparatus shown in Exhibits 668 and 673.

1864 The gravities were taken by the operators every thirty minutes and the gravities of the distillate were taken every thirty minutes. The gravity of the tar may have been taken every thirty minutes or at a little longer interval. The stream samples were taken, that is of the distillate and the tar, the reflux, either every hour or every two hours, and sent to the laboratory for complete distillation tests, gravity and distillation tests.

1865 DX 675 and DX 675-A are sketches of a special fractionating equipment which we used for the pur-

pose of making distillations and tests of our different charges and products.

1867 1334 These two sketches, sketch 5 and sketch 9, show a small fractionating equipment which was used for determining the amount of gasoline in the naphtha distillates of experiment 8 and also other experiments, and the charging stock. It consists of a small still, iron still, 8 inches in diameter and 11 inches deep, provided with three towers, a heavy, an intermediate and a light.

The still we will mark "A", the heavy tower "B", the intermediate tower "C" and the light tower "D".

These towers are connected by lines so the vapors can pass from the still up through the heavy tower B, thence down through the connecting line to the bottom of the intermediate tower C, thence from the top of the intermediate tower C to the bottom
1868 of the light tower D, thence from the top of the light tower D through the distillate line to the condenser coil E shown enclosed in the water box, thence to a receiver where the condensate is collected. This receiver we will call F.

The permanent gas passes through a line from the top of the receiver to the first of three absorption jars which are filled with absorption oil, and we will call the three G.

The gas passes to the bottom of the first absorption jar where it bubbles up through the absorption oil to the top of the jar, thence through a connecting pipe to the next absorption jar, to the bottom of the jar so that it can bubble up through the oil to the top of the absorption jar, thence in the same manner through the third absorption jar, thence through a connecting line to a gas collector marked H.

The towers are arranged in a step manner so that the bottoms of the towers can be connected.

The bottom of the light tower is connected
1869 1335 by a line so that the condensate will return to the bottom of the intermediate tower C. The condensate collecting in the intermediate tower will return through the connecting line back to the bottom of the tower B, where it combines with the condensate in tower B and flows back to the still.

The burner is not shown. This is merely heated with a Bunsen type burner or a ring type burner. That is placed immediately beneath the still. In making one of these distillations the material that collects in the receiver F is the condensate or the gasoline fractions. The casing head gasoline or light gasoline collect in the glass jar H. What is left in the iron tank A we call the naphtha bottoms, the naphtha distillate bottoms.

1870 In conducting one of these distillations, first you would measure out, say, 5,000 c.c. of oil and then you would light the fire gradually and heat it gradually until the temperature began to show up in the heavy tower, and continue the gradual heating until the vapors began to show in the second tower or the intermediate tower and then later in the light tower. Then the temperature would be controlled so as to get a certain rate, say 10 c.c. a minute or 15 c.c. a minute, or however well you wanted to fractionate, the fractionating depending a good deal upon the speed of distillation.

Then as the vapors coming over the top of the light tower D close into the condenser coil, the liquid fractions or the vapors, liquid at the ordinary temperature of the temperature of the water bath, begin collecting, and the first drip that you receive in the receiving drum is called the starting point.

1336 Then the temperature is gradually—that is the first reading at which we take the different temperatures of the still and the heavy tower B and the intermediate tower C and the light tower D is

1871 made.

I think in most cases we raised the temperature of the top of the light tower D 25 degrees and took the readings and took the gravities of the sample. Then that was continued up until 350 degrees Fahrenheit. Then those fractions were combined, which gives you the total naphtha at 350. But the distilling distillation was still continued at these 25 degree intervals, taking cuts at 25 degree intervals until we reached in some cases 400 degrees Fahrenheit. All these temperatures are in Fahrenheit.

The light naphtha collecting in the absorption jars would be shown by the increase in volume. That is,

they were usually filled with, say, 500 c.c. of absorption oil. Whatever would collect in the first would be the reading above 500 c.c., and so forth for the second and the third. Those differences or increases
1872 in volume were recorded as the amount of absorption of naphtha. The gas was measured and determined as collected in the gas receiver.

The practice that I followed subsequent to the gathering of the data on the particular tests that I made on this apparatus of DX 668 and DX 673-A was that after the data was all taken and all the tests had been delivered to my office, I went through the entire records and made all the necessary calculations, such as yield statements and yield statements from these fractional distillations, and then combined those computations to get an over-all yield on the basis of the charge.

1337 Then after looking over the records, in some cases, I made remarks at the ends of the reports. After I had finished and looked over the data that I had collected on these runs, I turned them over to Mr. Pond to copy in a record book data that
1873 we wanted to keep as a permanent record. The data that I obtained on the distillations were delivered to the office and we made records in the record book of all the combined and some other distillations.

The first operation was run 5 on May 25, 1917, and this turned out to be merely a preliminary operation because we were not able to get the apparatus to hold. There was so much leakage in the coils in those large return bends with the copper gaskets
1874 and in the manway that it turned out to be a matter of merely getting the apparatus so that it would hold and cut off the leakage. It was operated long enough so that we could tell at 100 pounds and 800 degrees inlet temperature on tube 14 that we couldn't get a very fast rate of cracking on this kind of oil.

This coil and drum experiment 8 was made up in part of the coil experiment No. 8, DX 666. That is, all the parts that were usable were incorporated
1875 in the installation of this experiment, coil and drum 8, such as the charging pumps, the distillate coil and box, the headers, gauges and thermometers and

things of that kind. As the first four runs were made on coil Experiment 8 shown in DX 666, the first run on coil and drum Experiment 8 was called run 5.

The next run, No. 6, made on the apparatus of the coil and drum was about May 30th, 1917.

1876 1338 DX 676 is some of the records that were kept in my file at The Texas Company of the
1877 experiments on this coil and drum run No. 6.

DX 676, page 1, is the first sheet of a running sheet that was made out for the operators to record
1878 the different data that was to be taken during the run.

Now, beginning at the left-hand upper corner you see it is marked "Experiment No. Coil 6". The date is May 30, 1917, page 1, and looking at the left-hand side, the headings at the top, the first item is "Time," recording of the time the data was taken.

The next item would be "Pump Strokes Double" and marked pump 1 and 2.

The next item or heading would be pressure in pounds, gauge pounds, and under this heading "Pressure" we find the different items, "Pump" pressure, "Coil Front", "Coil Back", "Drum", and "Rec. Drum".

Going over to the next heading, "Temperature F. Degrees", and under the first sub-heading would be "Coils", and that is indicated by points 1, 2, 3,
1879 4 and 5, and that is the record. That gives you the the temperatures of the coil from the start and intermediate points down to the bottom. Those are the thermometers that I have located on the drawing in my prior testimony. The next item is "Drum" and the next is "Vapor".

The next heading under "Temperature" is "Pyrometers", and the pyrometers are used when you take high temperature sections of the furnace, and the points 1, 2, 3, 4 and 5 indicate the different temperatures taken on the furnace.

1339 Those are also the points I have previously identified on the drawing. Now, the next item is "Tank Gauges." These are what we call the running tanks, supply tank, tar tank, distillate tank. Then the next item is "Gasometer". Those were tanks for collecting the gas. The next item is marked "Gravity". It should be naphtha distillate

gravity but you can tell by the gravities enumerated under it.

1880 Page 2 is a continuation of the running sheet, similar to page 1. Page 3 is the last sheet of the running sheet. Page 4 is merely the reverse of page
1881 3. Page 5 is a chart showing a continuous record of the temperature of the top of the light air condenser, or the air condenser.

Page 6 is the last chart showing the temperature, a continuous record of the temperature of the light air condenser. Page 7 is a record or chart showing the continuous record of the pressure of the coil. Page 8 is the last sheet or last chart showing the pressure, continuous pressure, at the end of the run. Page 9 is a tabulation showing the distillation tests of the samples that were taken during the run and sent to the laboratory for tests. Pages 10 to 14 are a continuation of the same tests.

1882 Page 15 is a sheet showing the calculations made on the charge, the residue and the distillate at each interval, and it also shows the gravities of the tar and the distillate and also the gas, cubic feet, at intervals. Page 16 is a continuation of page 15. Page 17 is a continuation from page 16. Page 18 is a tabulation of the yields of products and the remarks. Page 19 is notations as to the positions of the thermometers and the pyrometers as installed on
1340 the equipment. Page 20 is a fractional distillation of the stock that was made by this apparatus shown on DX 675-A and B.

Page 21 does not concern this experiment.

1883 The distillation of the stock on page 20 was to determine the amount of naphtha in the charging stock at the boiling range of the gasoline in the naphtha distillate. The entries on these run sheets were made in most cases by the still men. I might have made a few entries but most of them were entered by Mr. Pond and Paul Terrier. I was in charge of this operation.

As the operation proceeded, the operators were supposed to take the temperatures as nearly at the same time as possible. They would read those temperatures by just going up to the thermometers in the coil and looking at them and reading them. If

they couldn't see it they would pull the thermometer out and make a reading. If it was a recording they would take the reading as indicated by the recorder.
1884 Then they were immediately recorded on the running sheet.

This running sheet in which those records are so recorded are pages 1 to 4, inclusive of DX 676.

1886 I think these entries made in DX 676 accurately and truly reflect the conditions obtaining in the apparatus during this run 6 as nearly as is possible with a human operator.

1889 I believe that the distillations then made and now presented as to charge and products, etc., of run No. 6 truly reflect conditions. I have no doubt that they were all right.

1892 After the apparatus as shown on DX 673-A was headed up and the return bends put on and tested for pressure, after it was considered connected up sufficiently tight to start run No. 6, air pressure was let off so that the equipment was at atmospheric pressure, and then the fires were started.

1893 1341 After the fires had been going long enough to heat up the brick, the pumps were started and the oil was charged through the pump to the inlet of the coil then so that the oil could flow down through the coil continuously and down through the last tube into the drum.

Then the fires were brought up gradually and the charge continued.

1894 After the water was mostly out of the system, we closed the valves on the condenser coil. Then the tar line was closed and this draw-off from this U-bend closed and the pressure was brought up until the temperatures began to show in the air condenser. Then they checked on their fires and tried to get constant conditions, maintain a constant charge, maintain a constant distillate and draw the tar so as to get the oil level.

In run 6, the controlling point was the temperature at the inlet of this last tube, and the reason the temperature was taken there was that we didn't know how to install any instrument to take a correct temperature in a 3-inch pipe, or we didn't have means
1895 to do it, so we came over here at the inlet of tube 14 where we could make an installation and did the

best we knew how. In run 6 we maintained the temperature at the inlet of tube 14 at approximately 825 degrees. The pressure in the system was maintained at 200 pounds, approximately.

The distillate was run at a constant gravity of about 54 gravity. The tar was drawn so as to maintain a constant oil level in the liquid gauge or in the oil level gauge. The reflux that formed in the
1896 bottom part of the air condenser was returned through the return bend where it was picked up
1896 1342 by the charge and forced with it through the coil.

The best evidence that the backtrap was forced into the heating coil was whether the backtrap line was hot, and the next evidence, the color of the distillate. As far as I know the backtrap line was hot and the distillate was never off-color.

1897 Q. Now, was or was not during this run the backtrap line hot and the jet hot?

A. It was hot so far as the operators said and so far as I observed it myself. I know of no time when it was cold excepting at the start.

Q. You are referring to both the jet and backtrap line?

A. I am so far as my information is concerned it was operating continuously all the time. In fact these samples were taken out. I had them set them out in the laboratory where I could see them, in a row. Every sample that was taken out, of that distillate, I saw.

Mr. Hall: Your Honor, I want to object to this last answer and the two preceding answers as argumentative and a conclusion. There has been no statement by this witness, so far as I have observed, of the manner in which this apparatus worked. So far as I have observed he has entirely omitted all reference to this jet pump and he has just given a conclusion about the feed picking up what he has called the backtrap.

The Court: The objection will be overruled.

1896 1343 As I told you yesterday, the apparatus was designed so that it either had to function properly or it would puke this backtrap over into the distillate.

1897 During run 6 the backtrap line was hot so far as th. operators said and so far as I observed it myself. I kn. w of no time when it was cold excepting at the start.

1899 The next run was immediately following this, the first part of June, and that was run No. 7. We conducted run No. 7 in the same manner that I have outlined for run No. 6.

DX 677 is the records of experiment No. 8, run 1901 No 7. 6-10-17 is the day on which the run was started.

There was an attempt in this run No. 7 to obtain a faster rate of cracking, and to do that we tried to raise the pressure, to about 300 pounds, and to raise the temperature of this inlet of tube 14 to 850° temperature and find out the results under those conditions. I think we obtained above 250 pounds pressure, and we obtained the 850° temperature. The reason we didn't obtain the pressure that I was aiming at was that this equipment was not strong enough to stand the pressure and temperature to- 1903 gether. Sheets 3 and 4 of DX 677 give the tests of the products of Run No. 7, the distillate, the tar and the reflux.

1904 DX 678 is a record of run 8 in which the data is 1905 practically of the same nature as taken on the runs 6 and 7. This is dated 6-14-17.

1344 Run 8 was really to try to repeat run 7, that is, try to get a run at these higher temperatures and pressures; and we tried to get up to 875 degrees temperature and 300 pounds pressure. And we came 1906 a little nearer doing it. The temperature we got for a while, but a pressure of about 280 was as high as they could get.

The next run was during the same month, June, 1917, and was run No. 9. DX 679 is a record of run No. 9, dated 6-26-17.

On account of the leakage in these former runs, we 1907 decided to operate this run 9 more nearly at the operating conditions of run No. 6. And the only difference was the temperature of this inlet tube was raised about 25 degrees higher than on run No. 6: the pressure was about the same.

1908 My participation in the operation of runs 7, 8, and 9, and in the distillations conducted in connection with

those runs, was the same as I have testified with respect to run 6.

The charging stock that I used on runs 6, 7, 8 and 9 was paraffin base gas oil of about 37½° gravity. Runs 7 and 8 were discontinued because of leakage. Runs 6 and 9 were continued long enough to get the information that we needed. They were longer, but 7 and 8 operated at these higher temperatures, and were cut down short because we didn't want to coke up the equipment and we wanted to be sure we got a
1909 proper inspection of the tubes. In run 7 we were running too high a distillate, that is, we did not have equipment, it was not apportioned so we could make a balanced operation. And they were purposely cut down before there could be anything that would necessitate an emergency closing down.

The apparatus was practically the same in all of these runs, except for very minor changes.

1910 The jet pump built by Mr. Witherup was installed on this equipment, and so far as I know was
1345 never taken out of position from the first run
1910 to the last run. It was used in every run.

This jet pump of DX 671 was installed on the inlet of the first tube, at the top of the coil, and is so marked on the drawing, DX 673a. That jet was operated in this apparatus during these runs as follows:

1911 The charge enters through point C and flows past the needle valve point into the inlet of the inlet nozzle of the jet pump marked F. And as it flows through the discharge end of the inlet nozzle there is a flare so that the oil flowing through can pick up and entrain any liquid that might be in this chamber marked by DE surrounding. And the liquid flowing into the nozzle here is, by its velocity, to entrain and
1912 pick up the surrounding liquid here and force it ahead into the nozzle, the discharge nozzle of the jet pump marked G. The theory of it is the oil coming through this nozzle is the charging oil pumped on through. As the charging oil comes through that nozzle F, the velocity entrains and picks up the surrounding oil, which was the backtrap in this case, and forces it ahead into this nozzle, into the discharge
1913 nozzle marked G and then to the inlet end of the coil. The backtrap line is connected to the orifice marked DE and the backtrap is flowing from an air condenser

practically five feet above the elevation of this jet pump. It enters at the bottom of the jet, that is, flowing up from the bottom.

1914 So far as I know, what I wanted to do was to put the backtrap through there continuously as it was formed, and that system did it and it did it uni-
1346 formly. I am not an expert on jet pumps, but if I put in a device and it does the work, that is
1915 all that is necessary for my experiment. I can't tell you how much work or power the jet had, but here you have a 5-foot column of oil; you have two forces working on that. You have the jet and the oil head.

The head and the jet pump put that back trap through there uniformly and did the job we wanted done in that equipment. I know that because, in the
1916 first place, as I have explained it, the back trap line was hot. In the next place, the equipment was designed so that, if you had temperature gradient and a flow of hot oil and maintained the temperature in your drum and had a flow of vapor over into your air condenser, it either had to work or not work. It was impossible to do anything else.

1918 DX 680 is a note book that I kept for the still men, and sometimes myself, to make distillations and re-
1919 cord the results. It is a note book I kept, and there
1921 are parts of it in my own handwriting, from one day to another. This is the original data taken at the time the distillations were made.

1928 DX 681 is the permanent record book that I kept in my files. It contains the final report of the operation of each of these runs. I kept that book but Mr. Pond copied all of the material from the original records. The conclusions at page 79, for example, are
1931 in my handwriting. All the remarks were made by myself.

1932 I also kept some cards for my own use of very condensed information of the series of experiments. I kept those cards for ready reference, condenced, to give the information and to have that information to compare with other types of experiments.

DX 682 is typewritten copies of abbreviated in-
1933 formation concerning these experiments on the coil and drum. These cards were made up by me about the time the run was being made, and then later
1347 they have been typewritten.

The apparatus, method of operation, and pertinent drawings of Experiment 8 are described on one of the cards of DX 682, as follows:

"Coil still with decomposition drum & air condenser 200′ x 3″. Coil mounted in furnace connecting to insulated decomposition drum 6′ x 2′. An air cond. 5′ x 10″ is connected to top of decomp. drum by goose neck 4″ Pipe. The B.T. of air cond. is connected by U3″ Pipe to a jet pump in charging end of coil. The top of air condenser is connected to cond. coil 171′ x 1½″ XX heavy. Control valve between cond. coil & rec. drum. The chg. line enters the jet pump at top coil so as to pick up back trap from air cond. B.P. (1648) 9063; (1703) 10316; Sketch 23."

1942 PX 7, or DX 759, under date of June 20, 1917, from J. G. Detwiler to Mr. F. T. Manley is the report on runs No. 6, 7 and 8, made by Mr. Detwiler who was in charge of the research department of the Port Arthur works. The permanent record book that I kept in my files was turned over to him to make out the report after discussing it with me. Attached to the report are typewritten copies of the run data appearing in the permanent record book (DX 681) and in DX 676, 677 and 678. Also attached is a blueprint of drawing 1703-Y (DX 669).

1943 This report gives the following tabulation and results on runs 6, 7 and 8:

"Data on Run

	Run No. 6	Run No. 7	Run No. 8
Time of run	50.5 hours	19.75 hours	29.5 hours
Charge	1258.99 gals.	581.46 gals. (?)	1007.7 gals.
Distillate	363.72 " 28.88%	484.68 "	483.0 " 47.94%
Residue	846.68 " 67.26%	164.64 "	456.75 " 45.34%
Gas	1683.49 cu. ft. 2.0%	1487.9 cu. ft. 3.8%	2558.2 cu. ft. 3.8%
Carbon	Not determined	Not determined	Not determined
Average Pressure, coil	200 lbs.	200-260 lbs.	275-290 lbs.
Average pressure, Rec. drum	50 lbs.	50 lbs.	50 lbs.
Average temperature furnace	1200-1650	1200-1700	1200-1700
Average Temperature coil	550-830	550-850	550-875
Average vapor	480	500	450
Fuel oil burned	276 gals.	155 gals.	243.7 gals.

1348 "Redistillation of 7500 C. C. of the Distillate on Fractionating Still.

Naphtha to 375	57.68%–61.8 gr.	43.03%–61.2 gr.	45.28%–60.5 gr.
Bottoms above 375	40.05%	53.97%–37.6 gr.	50.33%–37.3 gr.
Naphtha in gases absorbed	1.29%	1.68%	2.53%
Loss distilling	1.18%	1.31%	1.86%

The Yield of Products by Volume on Basis of Volume of Oil Used.

Naphtha to 375	16.66%	32.12%	21.71%
Bottoms above 375	11.51%	40.29%	24.13%
Naphtha from absorp. of gas	0.37%	1.25%	1.21%
Still bottoms	67.26%	25.35%	45.34%
Gas—calculated to oil	2.00%	3.80%	3.80%
Loss distilling	0.34%	0.99%	0.89%
Other losses, leakage, etc.	1.86%	?	3.12%

1943 DX 683 is a letter by Mr. F. T. Manley to Mr. J. G. Detwiler under date of June 27, 1917, in response to his letter of the 20th of June, PX 7. I didn't receive a copy of the letter but I saw the letter some few days after Detwiler had received the letter, which reads in part:

"I have carefully noted your report of the 20th instant covering the above, and wish to say that there is a possibility of this process, if properly worked out, giving good results, and we hope you will be able to put this equipment in such condition as will prevent leakage, and that the next report will show that this feature has been taken care of.

"I think after experimenting with Paraffine Gas Oil it would be well to try Kerosene, also Unpressed Distillate to ascertain which would give the best results, running to the same temperature and pressure.

"I would be glad to have you follow this up carefully and let me have a report as promptly as possible."

1944 PX 8, a letter under date of August 10, 1917, from myself to F. T. Manley, is a report to Mr. Man-

1349 ley covering experiment No. 8, run No. 9. The
1944 following is a tabulation and summary of results:

"Summary:—

Time of Run from beginning to end	54 Hours 45 Min.	
Fuel Oil Burned	265.86 Gals.	
Stock	1324.173 Gals.	100.00%
Distillate	435.75 Gals.	32.91%
Residue	840.00 Gals.	63.44%
Gas: 2549.5 Cu. Ft.) Carbon: Undetermined)	48.423 Gals.	3.65%
Leakage: Very little)		

Fractional Distillation 7500 C. C. 51.8 Gravity

	Percent	Gravity
Naphtha start to 350	48.73	59.2
Naphtha start to 375	56.33	57.1
Absorp. Naphtha	2.68	
Bottoms above 375	39.20	38.9
Loss distilling	0.82	

Yield of Products by Volume Bases Stock

		Gallons	Percent	Gravity
Distillate:	Naphtha start to 350	212.4	16.04	59.2
32.91%	Naphtha start to 375	245.4	18.54	57.1
	Absorp. Naphtha	11.65	0.88	
	Bottoms above 375	170.9	12.90	38.9
	Loss distilling	7.8	0.59	
Residue		840.0	63.44	
Gas: 2549.5 Cu. Ft.) Carbon: undetermined)		48.423	3.65"	
Leakage: undetermined)				

My remarks on the report were:

"This experiment, as previous experiments with Paraffine Base Gas Oil as stock, demonstrates that the lower tubes carbonize considerably and the run, consequently, is of short duration. This difficulty with Paraffine Base Gas Oil can probably be very much overcome; first by lengthening the tubes so that it will not be necessary to carry such a high temperature in the furnace, and secondly, by increasing the velocity of oil and vapor through the tubes so that the carbon

will be swept along with the oil and vapor in the tubes."

"The product has qualities as good as the Burton Product, and the decomposition can be effected very rapidly."

1945 In response to the instructions directed to Mr. Detwiler from Mr. Manley, DX 683, we made two
1350 further runs, Nos. 10 and 11, on kerosene stock.

PX 9 and PX 10 are reports by myself to Mr. F. T. Manley of experiment No. 8, runs Nos. 10 and 11, which are abbreviated reports showing the operating conditions, tests of products, the yield, and my remarks at the end of the report. PX 10 reads in part:

"The object of the experiment was to try out this apparatus on kerosene, and ascertain whether the conditions of cracking could be obtained on this apparatus.

"The results are not very satisfactory because the conditions of rapid decomposition were never reached. Alterations and modifications will remedy this defect in the present apparatus for kerosene product.

"Carbon deposit was practically nothing."

PX 9 reads in part:

"This experiment, as Experiment 8, Run 10, demonstrates that it is impossible to reach the conditions of rapid decomposition in this apparatus. There must be more coil, more pressure and air condenser.

"Carbon deposit almost nothing."

"Mr. Hall: Your Honor, may I suggest that it would certainly aid the Court if instead of saying this is a letter that he sent to somebody about a certain run he would first give your Honor his present recollection of the history of that run, what he did, what he ran, generally what he did, and whether it was a failure or otherwise. Then you would have some
1946 idea what that run is instead of being compelled later either to consider these records yourself, which of course would be a very involved job, or have some other witness come on and try to explain to you what the records show. Now, it seems to me in the ordinary conduct of a case of this kind it would be much more understandable, and the witness could say it in a few minutes, that he ran kerosene, as he did, the

length of his run and what results he got. Then you would have his contention about that run.

"Mr. Thiess: We are not materially relying on these runs, but they have put in these letters with respect to these runs and I want the witness to
1351 identify the reports on these runs which they have put in.

"The Court: They are in, and if counsel offers the
1947 evidence along the lines you suggest, all right, and if not I will have to do without it, that is all."

1948 Kerosene being a much lighter stock and requiring a higher temperature and a higher pressure to obtain suitable cracking conditions, we were not able during the runs to get a desirable cracking rate. The engineering department had tried to reinforce the drum before we started the runs by reinforcing the flange on the manway, but even after that we couldn't get to 300 pounds. Being a much lighter stock we didn't obtain the temperature that we desired in the coil. The stock was so refractory and so light that it required more temperature and more pressure than we could obtain in this equipment.

1949 "Q. What was your conclusion regarding the merits of the process which you conducted in this apparatus after you had finished these runs 6 to 9?

"Mr. Haight: I think that is objectionable, if your Honor please. They will have to speak for themselves.

"The Court: I will have to sustain the objection to that.

"Mr. Thiess: Q. Were you satisfied with the results you received in these runs?

"Mr. Haight: I think that is the same thing and I object to it again.

"The Court: I don't see on what theory I can admit that, Mr. Thiess.

"Mr. Thiess: It was just suggested to me that it is true that in priority cases and interferences where you test out the question of priority as between rival inventors it is customary to ask the inventor whether the results he got were satisfactory.

1352 "The Court: It may be the custom but that
1950 does not have anything to do with the case.

"Mr. Hall: You understand, your Honor, in those cases they do not have a judge—

"The court: Whether he was satisfied or dissatisfied, whether the runs came out as he expected, doesn't have anything to do with the question that I will have to decide.

"Mr. Thiess: All right, we will let the record speak for itself."

DX 684 is a letter under date of August 14, 1917, from Mr. F. T. Manley to Mr. Detwiler. I received
1951 a copy of that letter the same day it was written, and it reads in part:

"I have Mr. Beheimer's report of the 10th instant covering experiment #8, runs 9 and 10, which I believe demonstrates conclusively that the equipment used will undoubtedly give us satisfactory results if properly arranged and constructed of suitable material.

"Please arrange as early as possible to order necessary material of proper kind to put up equipment which will enable us to prove the experiment is satisfactory and will give us the desired results in running paraffine gas oil.

"You will note from his report that the product produced is equal to that made on the Burton stills, and that decomposition can be effected very rapidly."

1962 1353 I immediately went ahead to make up a draw-
1963 ing to show the improvements in the apparatus to make a satisfactory operation.

One of the first things that we needed was more pressure. The next thing that we needed was a larger capacity, because in the small equipment the radiation loss was too great. The larger the equipment and the greater the volume of oil flowing through it the less radiation loss you have and the easier it is to maintain your working conditions.

The next improvement I wanted was in the coil. We wanted a coil that was smaller and longer so that it could be heated at a lower temperature, and the velocity through the coil would be sufficient to cut off all possibility of stratification of the oil in the
1964 coil, and as it was flowing through the coil it would have velocity enough to pick up these heavier particles of oil and sweep them along so they wouldn't be

overcracked. Also the pressure was to make it denser. We figured the denser the oil and the oil vapor the less likelihood there would be of coking trouble. The next improvement was to get a larger air condenser because the prior experiments had shown that at
1964 1354 the higher temperature we didn't have anywhere nearly enough cooling. We had to run too heavy a product. Another improvement was that we could heat the drum at the start or we could mildly heat it, if necessary, during the operation, so that we could get quickly to operating conditions.

Now the chief thing in this improved apparatus was to overcome carbon trouble. There was only one trouble in the cracking industry and that was carbon.
1965 If you could keep your surfaces clean there would be no trouble at all. So the chief improvement in this was to get pressure to increase the density of your vapors or possibly increase the liquid phase of the oil going through the system.

The next part is that it stratified. If the vapors would have velocity enough they would go through with such a force that any oil that might have a tendency to be heated on the bottom of the tube—it would be boiled by being heated from the bottom naturally—would be picked up by these vapors and make a froth or mixture, so that it would be carried over and overcome the local overheating. The trouble in this coil, the coking, as we conceived at that time, was the overheating, and we had to have this velocity and this turbulence of this frothy mixture to keep it from stratifying and being overheated and baked down on
1966 the bottom of the tube. So that is the reason we wanted to increase the length of the coil, to get a lower heat and also decrease the diameter of the tube so as to get a greater velocity as well.

1966 DX 685 is a sketch made up in my own hand in August or September, 1917, to be turned over to
1966 1355 the engineering department to draw up equipment to carry out the improvements that we had
1968 found that were necessary from these experiments. Harris A. Smith finally made up a drawing. I co-
1969 operated with Mr. Smith in the making of this drawing. DX 686 is original tracing Y 2200 dated 9/24/17, made by Harris A. Smith, in which the recommendations from my sketch were incorporated.

1970 The apparatus shown in DX 686 consists of a heating coil 1, a drum 2 and an air condenser 3, and the water box and condenser coil 4. However, this is not a complete drawing. It is a drawing just showing the parts that require improvement, that is, the things that are to be built in the shop. The heating coil consists of 2-inch internal diameter nickel steel tubing and when connected so the oil could flow from the inlet to the outlet it would have a length, a continuous length, of about 1,000 feet. That coil is shown in end view to the right of the main furnace.

1972 These pencil marks on DX 686 are where the draftsmen made changes that I had suggested in conference with them when we were going over the drawing.

1975 A drum 20 feet long by 4 feet in diameter is marked "2," and two air condensers in series are marked "3," and a condenser coil is marked "4." The heavy air condenser is connected by a reflux line or backtrap line 5 to the jet pump 6 at the coil inlet.

1976 One change was a change marked 7 in the vapor line to make it more compact. The next change was the tar line marked 8. This was connected up like the old-fashioned stills that they ran. They went in

1976 from the top of the still and dropped down, 1356 and we didn't want that in our system so we made a correction here at this point marked 9. So that the tar could be drawn directly out of the bottom of the still. Another change is the U-bend marked 10 at the jet so that we would have a liquid seal of the reflux coming through the jet.

1977 The wording "backtrap" means a change, which I have got down here as 11.

1978 The partial condenser comes down to a point and the backtrap comes off the bottom of it as indicated in pencil. It is drawn that way but I don't think the purpose was to lower it. I don't think this drawing is to show an elevation. It is merely drawn in to show the change, you see, to get it more direct instead of all these L's and fittings that give you trouble and leakage. The purpose is to eliminate the sources of leakage and run it directly over this way.

1979 The purpose of the pencil marks as to this vapor line was merely to simplify it and cut out a lot of extra unnecessary fittings. The U-bend marked "10"

was simply to have a liquid seal so that there could be no working of gases back from the inlet of the coil back up to the air condenser. The tar line change
1980 was so that instead of lifting any heavy oil or any coke they might get in the bottom, instead of pulling it up the line we could draw it immediately out of the bottom of that drum.

The engineering department, in an effort to secure the equipment and material and building the apparatus in accordance with DX 686, attempted to order a drum and they later made up a drawing and
1980 1357 specifications and sent it to the Kellogg Manufacturing Company to see if they couldn't build a drum of that size that would be safe to operate at this high pressure of 500 pounds.

1981 DX 687 is a letter dated Nov. 5, 1917, from Mr. Dawson, the purchasing agent at Houston, to Mr. A. S. Bailey, the chief engineer at the Port Arthur works. The attached letter is a letter from Mr. Colling, the manager of the purchasing department, to Mr. R. G. Dawson, and there is a note to me, "Please note and return." This is concerning the four-foot diameter by twenty-foot height pressure still, saying that they could build this drum for a certain amount.

1982 DX 688 is a letter to Mr. Bailey from myself, dated November 7, 1917, concerning this drum and concerning the coil that was to be built or that they were trying to design and build for this equipment. In part it reads:

"From the above letter it is evident that the Kellogg Company can build the high pressure drum needed for the coil experiment. Mr. Manley has in previous conversation given his approval to building the still for this experiment. Under these circumstances it seems advisable that we go over the still in detail and draw up final specifications for the construction of the drum.

"Also suitable connections should be decided upon for the coil ends and requisition placed for 2" pipe and end connections, and possibly requisition for 1½" and 3" pipe and end connections so we can try out different sized pipe in the experiment. Oil level gauges and valves and accessories requiring special construction should be taken up and requisition placed for same."

1983 DX 689 is a letter under date of November 8, 1917, from Mr. Bailey to myself concerning the pressure drum and as to taking the matter up with Mr. Manley as to the construction. We were at the point we 1983 1358 could get it. We never did get it, as far as I know.

DX 690 is a letter from Mr. Manley to Mr. Bailey under date of November 10, 1917. I got a copy of that letter, which reads in part:

"I have copy of your letter of the 8th instant to Behimer and note you estimate this experimental equipment will cost approximately $13,000.00. Before giving approval on this construction would be glad to have complete information in the way of estimate and requisitions to cover the material required.

"No doubt we will be able to get approval but it will be necessary to have all data in proper shape before presenting to the Executives."

DX 691 is a letter under date of December 14, 1917, 1985 from Mr. Bailey to Dawson, relative to procuring recommendations as to special flanges, elbows and return bends for a 2" pipe to withstand a working pressure of 500 lbs. at a temperature of 800° F.

DX 692 is a letter under date of January 3, 1918, 1986 "Pipe Fittings," F. P. Risdon to A. S. Bailey, in reply to DX 691 and stating that they have not been able to do better than cast steel fittings for such service.

After the changes or corrections indicated by me on DX 686, the matter was turned over to a new draftsman, Mr. Hartzler, who started to make up 1987 another drawing. DX 693 is an original pencil drawing which he made later on in December, 1917. That drawing was never completed. As it is, it was, but it was never completed to get out to the shop to be built. This drawing incorporates the changes that I have indicated in the drawing, DX 686, but some of them are not made in accordance with the way that I intended to have the changes made. This air condenser is not elevated sufficiently, according to my recollection of it. I wanted it mounted as a 1987 1359 normal air condenser is, mounted on a still. In the return of the jet pump, he entirely omitted 1988 that. He put in the U-bend and left the jet out. The

tar line correction is made according to the manner in which I wanted it.

1989 Hartzler was working particularly on how to get a return bend. There was a lot of work done on this because we didn't have any suitable heating coils for that high pressure.

1990 We had gotten onto some different line of work for a while, and we were occupied on that, and I missed the corrections or didn't have them done. If it had 1990 come back again, we would have made the corrections. Sometimes you drop out of your work and get onto something else; and it happened we got onto some other work and did not get back to this and get it completed. And it was dropped in an incomplete stage. Hartzler was working especially on, and what 1991 I was most interested in was, the coil and drum and jet. Those were the three things we had to have, had to have developed, and the other parts like air condenser and U-bends, why, we could do that on the job.

1994 The engineering department were not able to obtain the coil of the apparatus shown in the drawings, DX 686 and DX 693.

1995 I was working in conjunction, or keeping in touch, with the engineering department in the attempt to get a satisfactory coil. I personally knew about the in- 1996 ability to get this coil or to get the fittings, the return bends. I had several conferences with Mr. Hoffman of the Vilter Mfg. Co. later. For lower pressures they finally sent their regular fittings, which were eventually put in in December, 1919, on another equipment. I did not personally contact the pump 1996 1360 people at this particular time. It was a little later when I began to contact the representatives of manufacturers.

1998 This apparatus as shown on DX 686 and DX 693 was never built.

The next step was that in October, 1917, Mr. Holmes called Mr. Hull, the chief engineer of The Texas Company and myself to New York City for a conference, and at this conference Mr. Holmes told 1999 us that it would be necessary to get busy to make gasoline; that he had been working on a battery of 2000 five stills. We went over the drawings, and I told

Mr. Holmes that we had had considerable trouble in some smaller stills in maintaining oil levels and trouble with coke and getting gauges and valves and fittings, and it seemed to me too hazardous to attempt to put in a battery of five stills. Finally they compromised by arranging these five stills into three batteries, the first and second batteries with two stills, the third battery to be one still and I could have this one still to work on to put on a pre-heating coil and these different things if I could get them ready in time. These batteries were not to be operated at those high pressures that we have been talking about. The idea was to get something that they thought they could build at that time.

2002 I had been enthusiastic about the coil and drum process and I had been talking to Mr. Donaldson about a patent application continuously while doing the operation.

2003 When we were operating the equipment, Mr. Donaldson was there in the research laboratory, his
2003 1361 office was next to mine, and I discussed this patent proposition with him many different times trying to tell him the reasons and the things that he should incorporate in the description of the patent. And I thought at that time that he had been
2004 taking notes in getting ready. In December, 1917, he told me he was going to start to make a draft of the patent specification. Mr. Donaldson prepared such an application. I read over the draft that he had, different drafts that he had written and I criticized and discussed it with him at different times.

2005 DX 694 is the third draft of the patent specification; and on page 2 I find the notation that I made on the draft—a criticism concerning it or additions. And on page 7, I see another notation in my handwriting. I saw this application in the early part of 1918.

2006 DX 695 is a tracing which Mr. Donaldson had made up letter size to attach to the patent specification. This tracing was made January 4th, 1918.

2007 I had further contact with this application, after its preparation. In April, 1918, I had a discussion, rather brief discussion concerning this patent with

Dr. Mackenzie. We discussed the range of temperatures and what it was limited to.

2008 DX 620 is a letter of October 31, 1918, by myself, to Mr. K. G. Mackenzie, in which I recommended
2009 or suggested that it might be advisable to incorporate a claim covering more than one still, multiple stills with this coil and drum hookup.

In this letter, DX 620, by the reference to the "West Side pressure stills," I was referring to the batteries which were put in for commercial experimenting known as Experiment No. 18. Those are the three batteries previously described consisting of two batteries with two stills, and one battery with one still. These batteries were identified as bat-
2010 1362 teries 1, 2 and 3, experiment 18.

DX 697 is a photostatic copy of a blue print showing different sections of batteries 2 and 3.

2011 The first run on the batteries of experiment No. 18 was in April, 1918. The runs on the three batteries were operated at the same time.

2012 DX 698 is a blue print of a drawing dated July 2, 1918, showing different sectional views of the two inch heating coil which was installed on battery 3. At the suggestion of Mr. Hoffman of the Vilter Mfg. Co. we tried out their regular return bends for this lower pressure coil. The return bends operated very successfully after we had worked out a suitable gasket.

The reference on DX 698 "ammonia return bends"
2013 signifies that is the type of bend they use where they use ammonia for their refrigerators. These ammonia return bends were far more satisfactory; the only problem was the gasket. That permitted using higher pressures.

DX 699 is a letter of June 18th, 1918, from Mr.
2014 F. P. Risdon, to F. B. Capen who had charge of the construction of this equipment, concerning these ammonia return bends; it reads in part:

"We would like to have these flanges tested for both heat and pressure combined, if this is possible. There is no doubt in our mind but what either of these bends would be suitable for any pressure they would be called upon to stand in connection with the

experiments which are to be conducted, but as to whether the combination of heat and pressure will affect them any, we do not know, and would like to determine. We regret very much that we have been unable to secure these return bends at an earlier date but it was only yesterday that we received the one from the Vilter Manufacturing Company."

2014 1363 DX 700 is a letter under date of July 25, 1918, to The Texas Company from Vilter Manufacturing Company, reading in part:

"The matter of special return bends was thoroughly explained to us and we understood your requirements perfectly, but owing to the present conditions in the iron business and the difficulty of obtaining labor and material, we thought that standard return bends would suffice for your experimental plant provided we made special wrenches to draw up the bolts, which we are furnishing with this contract and we hope the same will prove satisfactory in every respect.

"We will be most pleased to make up special fittings for you in the future if we are granted sufficient time to do so as we desire to co-operate with you, as with all our customers, for the best ultimate results. We trust that you will call upon us when in need of fittings in the future so that we may obtain the necessary time to make up special fittings for you which will meet your requirements in every detail, especially for permanent work."

2015 DX 701 is a copy of a letter under date of September 13, 1918, from myself to Mr. Manley and relates to the operation of experiment 18. It shows that a preheater had been ordered for Battery 3 so that I could experiment with the coil. The letter reads in part:

"As soon as experimenting is done on Battery 2, wouldn't it be a good plan to make one battery of four stills from Batteries 1 & 2 and install in place of Battery 2 so the preheater on Battery 3 can be used in conjunction with the four stills?"

2016 After I had completed the design of the heating
2017 coil and the other equipment, I consulted Mr. Capen as to obtaining a jet pump. Mr. Capen was the

efficiency engineer who had constructed this equipment.

Battery 3 held about 100 barrels in comparison with about 150 gallons in the coil and drum experiment No. 8. It was 25 times as large, so I had
2017 1364 to get a larger pump for this experiment No. 18. We would have to have much greater pressure drop through our heating coil. The heating coil was approximately 1500 feet; it was two inch instead of three inches, and the charge would be at least 16 barrels an hour instead of a barrel; so we had 16 times as much charging going through a
2018 longer coil of a smaller diameter. I am speaking of the charge now, not including the back trap, the back trap would have increased that.

DX 703 is a letter under date of November 23, 1918, to Schutte & Koerting of Philadelphia, Pennsylvania, inquiring if they could supply us with a jet pump.

2019 DX 704 is a letter under date of December 2nd, 1918, from Schutte & Koerting Company to The Texas Company. It is in response to Mr. Capen's letter, DX 703, and requested additional data or information.

2020 We were going to have to furnish a lot of information and the management did not think it advisable
2021 or at least the matter was not taken any further, because of the policy of secrecy of the company about revealing the exact details of experiments which would be necessary to carry on the conversations further pertaining to this jet pump.

2022 We made up a jet pump in the shop but it would not do the work. I did not succeed in making a jet that could be used on this battery 3.

The heating coil that was designed and developed
2023 for this experiment No. 18 was installed in battery 3 in the summer or late summer of 1918. The first run was made in December, 1918.

DX 705 is a report of battery 3, run 5, experiment 18, giving the operating conditions of the run,
2023 1365 the yields and remarks concerning the run, and tests of products. This is the first run on which the coil was installed on battery 3. The reflux was returned to the bottom of the still. We returned

2024 the reflux to the bottom of the still because I had been unable to secure any device to return it to the heating coil in that experiment.

2025 The purpose of making Battery 3 with a single still was that—Mr. Holmes had said he would give 2026 that still to me to incorporate the return of the reflux back through the coil or to work out that part. As soon as I had worked out that part of it, it would be incorporated on the rest of the equipment.

In DX 664 which is the sketch I made of that Dewar and Redwood still, I proposed to return the reflux by gravity to the inlet of the 12 inch pipe still. 2027 In this case there would be practically no resistance to the flow of the vapors and oil through the still.

In designing our coil and drum operation we were interested in a pump for returning the reflux to the inlet of the coil because I always had the idea that we wanted to expand these experiments into a commercial operation and if we came to a commercial equipment with a high amount of oil to put through a restricted coil area we would have to have a considerable pressure in order to push it through the coil; and if we tried to use gravity we would have to go up three or four hundred feet in the air which would be a monstrosity of equipment. Then another thing, I wanted uniform flow through the coil. I wanted an instrument that when anything went by it would be passed and would not come back. If it was merely connected with the line—there would be irregularity in the operation, it would tend to 2028 1366 cause a surging back and forth and an irregular flow through the coil.

After we used the preheater coil on this single still 2029 operation Battery No. 3, and as we did not get a jet pump from an outside company, we went over to the machine shop and Mr. Fantz thought he could make up a jet pump that would do the work. We tested it out, and although our test did not show that it would pick up all the back trap through the resistance of that coil, we installed it and made one run in which I estimated that we put about 25 per cent of the reflux back through the coil with the charge.

Prior to doing that, we used this preheater coil on

one of the two still units. This coil on the first operation smoothed out the operation so much by putting the oil in the still at the required temperature and
2030 operated so much more smoothly that the superintendent, Tom Dillinger, was very anxious to put it on to one of the two still batteries.

DX 706 is a report on battery No. 2, run 14. This is the first run that we used the heating coil on the two still battery and we obtained "results better than any former run."

2031 The remarks contained on the last page of this report were made by myself. The remarks in part read:

"We must get busy on a jet that will force the back trap through the preheater. The capacity of our present preheater is about 20-25 barrels per hour. We need some experimental data so the jet and preheater can be proportioned."

2033 I worked in co-operation with Mr. Fantz. He was the mechanical genius, and after he would complete a jet I set up a small set up where I could install it in a line, connect the suction line with the drum at atmospheric pressure, and connect the inlet of the jet to a pump and meter and pressure gauges,
2033 1367 so that I could test it out. We made a number of different changes on the sizes of the throat.

2034 I selected the best jet and installed it on battery 3. That was about February, 1919.

DX 707 is the report on experiment 18, battery 3, run 7. This report is signed by me and I there stated:

"In the next experiment, an attempt will be made to jet the backtrap through the preheater. This will probably permit another reduction in furnace temperature and lessen the strain on the still inside the furnace."

DX 708 is a report on experiment 18, battery 3,
2035 run 8. The remarks at the end of DX 708 read as follows:

"Remarks: The object of the experiment was trying out jetting back trap through the preheater coil. The resistance in the coil was approximately 18 pounds gage pressure. This resistance was too great for this jet to pick up all the back trap. Approxi-

mately eight barrels per hour is the rate of flow of back trap and the jet was picking up only approxi-
mately two barrels per hour. As a result, approxi-
2036 mately six barrels per hour was running down vapor line to still."

By "running down vapor line to still" I referred to the fact that the air condenser, the back trap line and the vapor line were so installed that if the oil was not all being pumped by the jet through the heating coil it would back up into the bottom drum of the heavy air condenser and then flow back through the vapor line into the top of the still.

2037 We had been considering some time prior to this a battery of four stills, and about this time we decided to take batteries 2 and 3 and put the four stills into one battery of four stills. The management was working at this same time on a series of commercial batteries to be built and they wanted to put the four stills in a battery as they had decided, and get
2037 1368 busy and perfect the operation and make all of the improvements possible on the four still battery.

2038 DX 709 is a blue print of tracing H-405, and shows several views of this four still battery known as Battery No. 4 of experiment 18 that was constructed and started operating about April, 1919.

2040 On this operation with the four stills, we used the
2041 preheating coil that was installed on battery 3, and then later as that particular coil had insufficient capacity to heat the oil we installed another heating coil of approximately the same capacity.

About the first of March, 1919, I was called to New York and I called on the representative of the Hancock Inspirator Company in New York City relative
2042 to securing a jet pump and they recommended that I should go up to the factory in Boston. After securing the approval of Mr. Holmes, I visted their factory and talked over this proposition of a jet and they figured they could do the job but it would be necessary to continue some experimenting work back and forth in conjunction with us at the Port Arthur works.

DX 710-A is a letter from M. J. H. Miller of the Hancock Inspirator Company to me under date of

March 29, 1919, pertaining to this matter. I replied
2043 to that letter by a letter, DX 710-B, dated April the 21st, 1919.

DX 710-C is a letter written to The Texas Company, attention Otto Behimer, May 6, 1919, from the Hancock Inspirator Company, Mr. E. L. Berthold.

DX 710-D is a letter from F. T. Manley to me under
2043 date of May 20, 1919, which reads in part:

2044 1369 "I have noted copy of Mr. Miller's letter of March 29th and your reply of April 21st with reference to Jet pumps, for handling back traps from vertical stills. There is no question in my mind but that this can be worked out in due time, but we cannot well afford to do any experimenting on the six
2045 new batteries we are putting in, it being preferable to do all experimenting on the old battery which we are now operating.

"While we may not be able to design a jet pump which will do the work satisfactorily, I am sure we can make a centrifugal pump which will answer our purpose. I will be glad to discuss this with you and Fantz, our Machine Shop foreman, and have him make a small rotary pump for trial. If it gives satisfaction we can arrange to manufacture them ourselves."

2046 We operated this battery with four stills from about the first of April until the first of December, 1919. On the last run we had a fire and the damage was so great that they just decided to dismantle the still. One reason they dismantled them was that the battery was right in the line of the new commercial batteries that were being built; they had to remove them.

The Texas Company had been considering building commercial cracking stills at the time that I was
2047 called into conference with Mr. R. C. Holmes in October, 1917. The commercial construction of those stills was started while we were operating experiment 18. They began laying the foundation about the middle of 1919.

2048 DX 711 is a report on experiment 18, battery 4, run 3. This report has my signature and is dated 4-26-19; it reads in part:

"The preheater is not large enough. Another 2"

preheater is being put in. Two 2" preheaters will be enough to heat the charge for a four still battery when running at the rate of 25 to 30 bbls. distillate per hour; but the resistance in the pipe will eliminate the idea of jetting the back trap through the 2048 1370 preheater, on account of high resistance through the coils. For this reason a 3" preheater ought to be installed as soon as possible for experimental purposes."

• • • • • •

" • • • Taking the results of these experiments as a basis, a fairly good estimate can be made of the requirements for the new equipment of four still Batteries and that there may be no misunderstanding, a few requirements for the new batteries of four stills will be given below, based on the results of experiments so far performed.

• • • • • •

"(3) There should be left space for two 3" preheaters to each battery. One 3" preheater will probably heat the charge but if the back trap is to be jetted through the preheater it will be necessary to have two 3" preheaters.

"(4) There are a great many ways these stills could be operated and get fairly good results; but if the best results are to be obtained these stills must be operated so as to maintain the desired cracking temperatures in every part of every still. There are probably only two ways in which this result can be accomplishd depending upon the handling of the back trap.

"Method 1.

"(A) When the back trap is run directly from the heavy air condenser to the still i. e. without running through the preheater, the best method of operating would probably be to preheat the charge 800-850° F. and split the charge between stills 1, 2 & 3; draw tar from the bottom of still 4; connect the stills at top as in present battery by 12" oil over-flow line and 12" vapor line; take the vapors off still 4; run the back trap down the vapor line; but to prevent the back trap from running into still 4 connect a back trap line from vapor line next to top of still 1.

"The advantages of this method (1)

"(1) The temperature condition can be maintained in all parts of the still; for it cuts off the cooling effect of the back trap on the bottom of the still.

"(2) Fuel economy. The back trap cools the hot vapors coming directly from the still.

"(3) The carbon formation is split up between stills 1, 2 & 3.

"The Disadvantages of method 1.

"(1) Promotes the formation of Kerosene and will require greater pressure to run given gravity products.

2048 1371 "(2) Cuts off agitation and mixing of oil in stills consequently greater tendency for carbon formation in bottom of stills.

"Method 2.

When the back trap is jetted by the charge through the preheater, the best method of operating is to heat the charge and back trap 800-850° F. and split the charge between stills 1, 2 and 3; draw tar from bottom of still 4; connect the stills at top as in present battery by 12" oil over flow and 12" vapor line; take the vapors off still 4.

"The advantages of method 2:

"(1) The temperature conditions can be maintained in all parts of the stills.

"(2) The back trap is blended with the charge and heated to 850. The cracking of the back trap is promoted not only by its passage through the coil but also by the passage up through the hot oil in still.

"(3) It splits the carbon formation between stills 1, 2 & 3 and prevents to a greater extent the deposit of heavy oil and carbon in the bottoms of stills 1, 2 and 3.

"(4) It is an internal heating scheme and makes possible a lower furnace temperature.

"Method 2 is in my opinion the best method of all; at present the jet pump has not been worked out. It will require some experimenting with a 3" coil and jet pump before it will be ready, for that reason it seems to me it is advisable to plan space in the new equipment for two 3" preheaters with each bat-

tery of 4 stills, then when the jet pump is developed it can be easily installed."

The construction of commercial cracking stills at The Texas Company plant at Port Arthur began very early, but I cannot just set a date on it. It looked
2049 sometimes like the commercial part was proceeding faster than the experimental part. All the remarks on DX 711 were made by myself.

About June or July of 1919, Mr. Wilkie and I were
2050 directed to investigate the Blair process which was being demonstrated in Los Angeles. We were
2050 1372 there about a month conducting these experiments. On the way back we were interested in some electrical experiments being conducted, and I called on Mr. Cherry, who had an electric cracking process in Kansas City, Missouri.

2051 Later I talked to a Mr. Candor, who was in the sales department of The Texas Company, and in my conversation with him he seemed to be very familiar with mechanical work, and he made a suggestion to use the charge for operating what we call a steam driven pump.

DX 712 is a letter under date of December 6, 1919, from me to Mr. R. C. Holmes, concerning Mr. Candor and explaining that I believed he had suggested a good scheme for preheating the back trap.

2052 DX 713 is a letter from Mr. Holmes to me under date of December 31, 1919, in reply to DX 712, and which reads:

"I have your letter of the 8th inst. relative to E. R. Candor and while I am glad to have your comment relative to this party and to know of his special experience or abilities, I am disappointed that you should have discussed any feature of our pressure still work with him."

2053 I had been trying for some time to get smaller equipment so we could experiment a little faster on different phases of the four-still battery. The first attempt was in '18 and then when this fire on Battery 4 happened, the old operators that I had had on the earlier experiments were free so I could have them to carry on the small experiments. So I received permission to construct a small battery of four stills,

which was to be used to develop pumps, floats,
2053 1373 valves, gauges, and the best methods of operation for a battery of that kind.

2054 The unit was built in the year 1920, and was operated as experiment 11-B starting in April, 1920.

DX 714 is a detail drawing of the heating coil used on this battery of four stills, Experiment 11-B. DX 715 is a drawing showing the arrangement of the furnace and the stills and the scrapers and the air condensers, or different views of this experiment 11-B.

2059 One of the chief purposes was to find out the best kind of a pump to return the reflux back to the heating coil. The first pump that was used was a jet pump that was made up in the machine shop by Mr. Fantz, tested out and put onto this equipment. That "functioned all right." There was no trouble in this because the resistance was very little through the coil. DX
2060 716 is a couple of papers having some notations as to the inlet throat and the outlet throat of the jet giving the dimensions and on this jet No. 7 it gives a
2061 test of the jet pump with cold oil. This Fantz jet pump operated satisfactorily on Experiment 11-B. It would not operate on a large commercial operation because a jet has to be designed specifically for the work to be done.

Other devices which we worked with in an effort to
2062 get a satisfactory pumping means to return the reflux through the pre-heater coil are these: A device that was an idea Mr. White had. His idea was to take the vapors that were coming off of the air condenser and use them in place of the steam to operate the pump. The liquid end of the pump would pump the back trap and the vapors off of the air con-
2062 1374 denser would operate the steam end of the pump.

It was not satisfactory because the vapors seemed to cut the packing and there was too much leakage.

The next pump we used was a Candor pump, in which we put the charging oil into the steam end of the pump. That did not work, but I wrote a letter, DX 717-A, dated February 19, 1920, to the American Steam Pump Company, and they replied, DX 717-B, February 25, 1920, that it would have to be changed

in design to use the liquid to take the place of the steam.

2064 DX 718-A is a letter under date of March 3, 1920, that I wrote to W. E. Quimby, Inc., Newark, New Jersey, with relation to a pump for returning the reflux.

DX 718-B is a letter under date of March 13, 1920, to The Texas Company from W. E. Quimby, Inc. in reply to my letter, DX 718-A, stating it was a difficult problem unless accomplished electrically and recommending one of their screw pumps.

2066 DX 719-A is a letter under date of May 20, 1920, from me to The Ohio Injector Company in connection with the pump or jet pump to return the backtrap to the heating coil. DX 719-B is their letter in reply, dated May 25, 1920.

2067 DX 720 is a blue print of tracing Y 4422 of a centrifugal pump as proposed by George White. George White was the man that was in charge of the opera-
2068 tion of this experiment 11-B under my supervision. This pump was never built. There was a rotary pump built of a different design. It was by Mr. Parish. That didn't work because the heat caused an expension and it stuck and froze and we never prefected it
2068 1375 sufficiently to make it operate under those conditions.

2070 The next proposition Mr. Fantz and I worked out together was to use a single acting plunger pump in which the arms or the packing was extended by a collar so as to be, say, 22 feet or so, or more, away from the hot coil end of the pump, and this was mounted vertically so the cooler oil settled down.

Immediately Mr. Fantz suggested to make it a double acting pump so as to overcome the vibration. To do this it was necessary to mount it horizontally so the cooling arms or the connecting rod was extended the same as the former pump.

2071 These plunger pumps that Mr. Fantz was building came about February or March, 1921.

"Q. Did that pump operate successfully or not?

"A. The horizontal double acting plunger type
2072 pump worked very well.

"Mr. Hall: I object to that as a conclusion.

"The Court: All right, that will be stricken. Objection will be sustained."

DX 721-A, a drawing marked "89", is a representation of the Parish rotary pump which we tried for two runs on the equipment. DX 721-B, a drawing marked No. 90, is some rough drawings, part by Mr. Fantz and part by myself, concerning the plunger type pump that was used on this equipment.

2073 I took up the question of getting a pump with The Kinney Manufacturing Company. DX 722-A is a letter under date of December 28, 1920. DX 722-B is a letter under date of January 18, 1921, to E. F. Bender of The Kinney Manufacturing Company. Those letters refer to the procurement of a pump.

2074 DX 723 is a blueprint which shows in detail the Fantz horizontal double acting plunger type pump with the packing glands extended so as to be removed from th hot oil body of the pump. We installed this 2075 pump in experiment 11-B and operated for a few runs, up until the time we put on the Dow type 2075 1376 of pump. Those runs continued a hundred hours or more. There was a little trouble in the way of burning out packing while this pump was operated to return the reflux to the coil, but I should say it operated very satisfactorily. By satisfactory I mean it returned hot reflux to the inlet of the pre-heating coil. This operation was conducted about April, 1921.

2069 One reason why we stopped the experimenting was that we received a letter from the Dow people, and this looked like we could put this into operation at the plant. We could use an ordinary pump. That is, we had gotten something that there would be no trouble of installing on a small equipment or a large equipment.

2077 DX 724 is a letter from the Dow Pump & Deisel Engine Company to The Texas Company, a copy of which Mr. Capen sent me. I got that letter shortly after March 23, 1921. It called our attention to a hot oil pump which they claimed operated satisfactorily. The sketch attached to the letter is a drawing showing the connections or plan of the connections of this Dow surge pump. When I received a copy of this letter, we immediately started to make arrangements to install this Dow surge pump principle on 11-B and then a short time thereafter we started to 2078 install it on the commercial battery.

Upon receipt of DX 724, the first thing I did was that I wrote Capen a notegram (DX 725) dated April 9; 1921, which reads:

1377 "This is just what I am looking for. We intend trying the idea out in connection with the Worthington Pump. It is too simple to be true."

DX 727 is a notegram under date of May 3, 1921, which I sent to Mr. Dodge in response to the same letter that I received from Mr. Capen; it reads:

"This is no doubt by far the best scheme suggested up to present time for handling the back trap or hot residuums, and is being made up with slight modification to be installed on Battery No. 14 between heavy air condenser and preheater inlet."

One of these Dow surge pumps was constructed for our apparatus 11-B. It returned the reflux through the heating coils. There was some trouble, that

1378 is, in perfecting it in the beginning, but it was capable of doing the work that was to be done. It was operated on experiment 11-B after we had finished proportioning and getting up to a suitable size, from about May, 1921, until some time in 1923.

DX 728 is a blue print of tracing X 4644 in which the liquid end of the surge pump part is shown. This is best shown at the middle bottom of the blueprint.

The secret of the operation of these Dow surge pumps is the hot oil doesn't touch any of the moving parts. You can move the moving parts of the pump to where the oil is cold. High pressure pumps have been in operation for many years that could be operated that way but you couldn't operate them in the hot oil. Therefore, you would take the valve system out of a cold oil pump, and stretch it out twenty or thirty or forty feet where the hot oil was, and these surge lines leading back to the pump could be maintained cool so that the valves and this abrasion and different things you would get in the moving part would not bother you. It made it a simple proposition.

On or about that time, there was an operation conducted at The Texas Company in which they were commercially cracking gasoline, but in that operation the backtrap or reflux was not returned to the inlet of the heating coil. It was returned to the bottom of

the still because we had no means of returning it back to the heating coil.

DX 729 is a drawing showing diagrammatically the stills as commercially operated at this time at Port Arthur Works. They were started in March, 1920.

2093 1379 Referring to DX 729, the fresh charge flows through the exchanger coil 1, thence to the economizer coil 2, thence to the inlet of the heating coil at the top 3, thence out of the heating coil outlet to the stills, which is manifolded so as any one or all of the stills could be charged.

The oil accumulates in the stills and the level is maintained above the brick work so that the oil equalizes through the oil equalizing line. The oil flows from the heating coil outlet into the bottom of the stills 5, any one of them or all of them, as is desired. Then the oil fills up so as to cover the oil levels marked 4. Above the oil level there is a
2094 vapor equalizing line marked 6 whereby the vapor accumulating in the top of the stills can equalize and flow through from the still top through the vapor equalizing lines to the still 4, where the vapors, the combined vapors from all the stills, go into the bottom of the heavy air condenser marked 7. The vapors rising from the top or coming out of the top of the heavy air condenser flow through a vapor line to the bottom of the intermediate air condenser 8. The vapors flowing from the top of the intermediate air condenser flow to the bottom of the light air condenser 9. Thence the uncondensed vapors flow out of the top of the light air condenser to the condensing coil 10. The condensate and gas flow through the pressure regulating valve marked 11 to the accumulator marked 12, where the gas is taken off of the top and the naphtha is drawn to tankage at the bottom, naphtha being the product that contains the gasoline, the desired product.

2095 1380 The backtrap from the light air condenser and the intermediate air condenser flows back into the heavy air condenser 7 where the combined backtrap flows through line 13 to a manifold valve, manifolded so that the backtrap can be run to any or all of the stills, the bottom of any or all of the stills.

The tar line manifold is valved so that you can draw tar from any one of the four stills. Tar is drawn through tar line 14 to the tar heat exchanger shell where it flows around the heating coil and thence out of the bottom of the tar heat exchanger drum 15, to the cooling coil 16, and thence to the tar tank.

2096 In this operation none of the residuum that is withdrawn is ever returned to the system. The pressure is maintained by valve 11 in the outlet line of the condenser coil, that is, between the condenser coil and the receiving drum. Twenty-four batteries of the type shown on DX 729 were installed at Port Arthur at this time (May, 1921).

The approximate temperatures and pressures that
2097 were used in this apparatus, DX 729, were these: The cold oil which is at atmospheric temperature flows through the tar heat exchanger bringing the oil to approximately 300 degrees temperature, thence through the economizer where it is heated by the waste gases from the furnace and brought up to a temperature of approximately 400, thence through the heating coil where it is brought to 825 temperature, the heating coil outlet temperature of 825; thence to the stills where the temperature is
2097 1381 maintained from—approximately 770 degrees temperature. The vapor collecting in the top of
2098 the stills flows through the vapor line to the heavy air condenser which is approximately 700 degrees, thence to the intermediate air condenser, which is about 650, to the light air condenser at which the
2099 temperature of the vapors is about 600. The pressure on the still was, I think, about 150 pounds or slightly above 150, to 200 pounds, at the control valve 11.

2103 We first installed a Dow surge pump on the commercial cracking apparatus in July of the same year,
2104 1921. I cooperated in connection with this operation; I was following the work right along.

DX 730 is a blue print showing the general arrangement of the installation of the first surge pump on battery 14, run 52. Battery 14 is one of the regular commercial operations. The date of DX 730 is 5-21-21.

2105 DX 731 is a blue print which shows the second

type of installation in which the surge blocks were mounted under the condenser box instead of on top of the condenser water box just below the heavy air condenser. These diagrammatic drawings in the center of the drawing, DX 731, are to represent the operation of the pump. The date of the drawing, DX 731, is 11-8-21.

2106 The large commercial still, battery 14, was oper-
2107 ated with the Dow pump. In operating it with the Dow surge pump, we encountered some difficulty but it was, I would say, of a negligible nature. We put a line over from the charging line so we could discharge into the surge line in case there was
2107 1382 leakage or for any reason it got hot.

After we had gotten started and made several runs the pump returned practically all of the back trap to the heating coil. There might have been a few times in the first part when it did not.

After we had installed this Dow surge pump on
2108 battery 14, as soon as they could get the pumps and also bubble towers because later on they changed over to bubble towers, every battery of the remainder of the 24 batteries that were installed at Port Arthur was changed over to a surge pump and the bubble tower. I would say about the latter part of 1923 they were all provided with Dow surge pumps.

After that we did not operate any of our stills without the use of a Dow surge pump to return the reflux to the inlet of the heating coil up until the fall of
2109 1927, when I left the employment of The Texas Company. At that time, The Texas Company had over a hundred batteries at various plants using this Dow surge pump to return the back trap and reflux to the inlet of the heating coil.

DX 732 is what we call a flow diagram in order to indicate the operation of battery 14, run No. 63.

As compared to the flow diagram shown on DX 729, the only difference in these two batteries is in the hookup from the bottom of the heavy air condenser to the rest of the still. In DX 729, the back trap returns by gravity to a header where it can be returned to the bottom of any of the stills, any of the
2111 four stills. In DX 732, the reflux is returned
2111 1383 from the bottom of the heavy air gas condenser to the suction side of the check valve section

marked A of the surge pump and thence discharged through the outlet of the check valve system marked B, where it combines with the charge at the economizer outlet; thence combined with the charge, flows to the
2112 inlet of the preheating coil or heating coil, where it can be heated to the required temperature before being introduced into any one of the three stills.

After the original 24 batteries had been converted into batteries in which we used the Dow surge pump, the operation of those stills and the others that I mentioned are practically the same as the operation just given for the flow diagram DX 732, except the change was made to the bubble tower. The pump worked so that you could take suction from the bottom and there was no trouble in delivering the back trap back to the coil. The bubble tower took the place
2113 of what we call the air condenser section.

2114 The pressures and temperatures and the charging rate and the test of products shown on DX 732 were obtained from the run sheets. I checked that infor-
2115 mation from the operating records of run 63, and the operating figures shown on DX 732 are correct and accord with the operating data which was tabulated for this run 63. The conditions shown are averages
2116 for the last 50 hours or 55 hours under operating conditions.

The operating conditions of run 63, Battery 14, are: Beginning with the fresh charge, the battery is being fed from the pump house through a meter at the rate of 46.2 barrels per hour, and 280 pounds pres-
2116 1384 sure, at 86 degrees Fahrenheit; and the fresh charge has a gravity of 26 A. P. I., and initial boiling point of 450, and 591, 50 per cent. That means 50 per cent was in that temperature. The
2117 charge then passes through the tar heat exchanger coil, and passes out at a temperature of 321 degrees Fahrenheit; thence through the economizer where it is raised to 448 degrees Fahrenheit; at this point it combines with the back trap, from the surge pump with 68.2 barrels per hour at 667 degrees Fahrenheit. The back trap and the charge combined, totals 114.4 barrels at 581 degrees Fahrenheit, and under 258 pounds gage pressure. Thence it passes through the heating coil, and thence out of the heating coil at a temperature of 824 degrees Fahrenheit and 178 pounds

pressure. It is then distributed between stills 1, 2 and 3. The oil in the bottom of the stills is at these temperatures reading from the left-hand side, still 1 at the bottom has an oil temperature of 792 degrees Fahrenheit; still No. 2, 781 degrees Fahrenheit; still No. 3, 789 degrees Fahrenheit, and still No. 4, 768 degrees Fahrenheit. The oil temperature at the top of the stills is as follows: Still 1, 772 Fahrenheit, still 2, 759, still 3, 775, and still 4, 761 degrees Fahrenheit.

2118 The vapors collecting in the tubes of the stills pass through the vapor equalizing line to the fourth still where the total vapor generated passes through the vapor line to the bottom of the heavy air condenser.

The vapor passing over the top of the heavy air condenser is 687 Fahrenheit; thence to the top
2118 1385 of the intermediate condenser to the top of the light air condenser.

The temperature of the vapor at the outlet of the light air condenser is 158 degrees. The vapors from the light air condenser pass through the naphtha condenser cooling coil where the condensible vapors are condensed and collect in the bottom of the receiving drum and are drawn thence to tankage. The naphtha distillate was being formed at the rate of 7.3 barrels
2119 per hour, for 37.4 percentage, I think, and 50.7 A. P. I. gravity and 501 end point. The gas passes out of the top of the receiving drum to the gas plant or gas main.

Now coming back to the back trap which collects in the bottom of the heavy air condenser, that flows down to the suction side of the check valve system of the surge pump. This is pumped by this device out of the surge check valve system and discharged at a pressure of 267 pounds. And, as I stated before, this combines with the fresh charge at the outlet of the economizer and coil outlet, where the combined streams enter the heating coil inlet.

The tar is drawn from all the stills continuously or intermittently from the fourth still and usually by shots at longer intervals, much longer intervals from the other three stills.

The tar is drawn from the bottom of the stills into
2120 a header and through the tar line at 601 degrees Fahrenheit temperature at the inlet of the tar heat

exchanger. It comes out of the tar heat ex-
2120 1386 changer or comes out of the tar receiver at 323 degrees Fahrenheit; and then goes into a cooling coil, a water cooled coil and it is flowing at the rate of 26.9 barrels per hour, or 58.2 per cent of the charge, 18.6 A. P. I. gravity, 460 initial boiling point and 510 per cent distillate off 514 degrees Fahrenheit.

The notation at the bottom of the drawing "Fires ignited 10-31-21, fires cut 11-3-21" means the still was run during that period.

2121 In these operations on the commercial stills, after we had installed the Dow surge pump, we always returned the back-trap to the heating coil in all of them and none of the residue was ever returned to the system after it was withdrawn.

1387 *Cross-Examination by Mr. Thomas.*

2138 I worked for the Cross Brothers on cracking experiments prior to my employment by The Texas
2139 Company. After one week of employment at The Texas Company, I was assigned to, and for several years thereafter worked on, cracking problems of The Texas Company.

2140 When I first went to Port Arthur, The Texas Company had a small shed which was known as the experimental laboratory. In 1916, it built a large research laboratory and I was assigned to it.

In my work from 1916 on, I had the benefit of the technical facilities and resources of The Texas Company. It was in urgent need of a commercial cracking process at that time.

2141 Last year (1939) I voluntarily appeared as a witness in the suit of The Texas Company *vs.* Anderson-Prichard in Oklahoma. My testimony there covered the same subject matter as the direct examination in this case. The Texas Company sued the Anderson-Prichard Company on Behimer Patent No. 1,883,850. This patent purports to cover the experimental work I did back in 1916 or '17 at The Texas Company.

2142 I collaborated and had many round table discussions with counsel for The Texas Company and coun-
2143 sel for defendant and participated in the numerous discussions with Mr. Mace, of the Texas Company,

and Mr. Thiess. My direct testimony in this case was not written up in question and answer form. It was only an outline of things to be covered without any prepared answers. It was merely questions and material to be covered. The outline was made in December.

2144 1388 Dewar and Redwood Experiments:

My early experimental work in 1916 and 1917 was in connection with three variants of the Dewar and
2145 Redwood process. In all three of these variants there was a vessel with a body of oil in the lower part and above this, an enlarged vapor space. In the first operation, the flames passed directly over both the liquid and the vapor containing portions of the drum. In the second operation, the brickwork was dropped so that the flames would impinge directly on the vessel.

2146 The third variant of the Dewar and Redwood still was operated prior to, concurrently with and even
2147 after Experiment 8, coil and drum. This third variant was constructed and operated after my alleged conception of the coil and drum experiment. In this variant of the Redwood apparatus, the reflux was returned by gravity to the shell. There was no friction pressure trouble to overcome.

2148 I could not succeed with the Dewar and Redwood type of still because of too much carbon trouble.
2149 I wanted to make a continuous still to avoid carbon trouble. A process wherein oil was directly heated
2150 in the large vessel seemed to be out of the question. One reason the Dewar and Redwood operation was rejected was because of the accumulation of carbon in the heating vessel. Another reason was that Mr. Holmes suggested a vertical still for removing the carbon residuum which seemed to be a much better type for continuous process. I recognize, however, that the deposition of carbon on the walls of a heating vessal is a cracking process is a very baneful thing, and that you can't succeed where there
1389 is any substantial deposition of carbon on the heating element of a cracking process.

2146 The Dewar and Redwood variants had all the defects and infirmities of the Burton still.

I had my first conception of "clean circulation" on February 25, 1916.

2151 About fourteen years ago, that is, in 1926, when I was in the employ of The Texas Company, I prepared a statement covering my activities at the plant of The Texas Company in collaboration with an expert, Mr. McCarthy, and Mr. Mace, counsel for The
2153 Texas Company. I don't think we went into the reports to check up things thoroughly. This statement was offered in evidence in the Anderson-Prichard suit as Defendant's Exhibit 507. In it, I said, with regard to the conception of "clean circulation,"

2154 "To the best of my present recollection the date of the conception of this idea was about the first of August, 1916.

"Q. I call your attention to Defendant's Exhibit 664. Does that sketch exemplify an apparatus by which you proposed to carry out this invention that you had called clean circulation?

"A. This in itself was trying to work out an improvement on the Redwood apparatus.

"Q. But at the time of that sketch you had not reached the clean circulation invention?

"A. Oh, no.

2155 "Q. Now I understood you to say that after the conception of your invention—

"A. Let me ask you a question. Let's see if I understand your former question.

"Mr. Thomas: Read the question.

(The question was read.)

1390 "Mr. Reichmann: And the answer.

(The answer was read.)

"The Witness: Look here. That sketch—I don't know whether that sketch was made shortly after the experiment of this 2/25, February 25, 1916, or whether I made it at some later time when we were building this last modification of the Redwood in trying to work out an improved Redwood equipment. As far as having the idea, as I say, as my recollection tells me now and after what we have gone through and with other information that I had, the idea of the clean circulation was near this 2/25/16."

2156 Behimer Disclosure:

I disclosed the invention to Donaldson, a patent attorney for The Texas Company. I had a concept of a process that I thought you could employ in making gasoline a continuous process, but I didn't have a concept at that time of any means for giving this operation expression. I didn't know how to do it. I didn't know of any pump that would do the work.

2157 The use of gravity return was evident but I was only interested in a mechanical means so that I could make a positive return and that was what I was disclosing.

In the Anderson-Prichard case, I testified as follows:

2158 "Q. When you disclosed your idea to Mr. Donaldson in the latter part of 1916, you knew all about tank cracking?

"A. Yes, sir.

"Q. And you at that time didn't know of any means, jet or any other means, for returning back-trap or reflux through a coil back to a tank at the time you disclosed this to Mr. Donaldson?

"A. I didn't."

2159 Also in the same case, I testified in reference to the disclosure to Mr. Donaldson as follows:

1391 "Q. Did you explain to him anything at all about how you were to get the reflux back into the coil?

"A. Well, at that time that was still a problem. That was the first trouble with this scheme. We did not know of any device to do that."

2160 In the same case, I also testified:

"Q. Did you tell Mr. Donaldson that? State what you did tell Mr. Donaldson in regard to getting it back in the coil.

"A. I don't remember just what I said, but I most surely said that we didn't have the means, but I remember, I told him what I thought would be a good thing for a patentable scheme, and I thought it was something that would eventually work out."

2161 I also disclosed my scheme to Mr. Holmes, who was the general manager of The Texas Company in charge

of cracking and refining. All this work was under his supervision and control. Mr. Manley who was associated with Mr. Holmes in that work, was superintendent of the Port Arthur works. It is my recol-
2162 lection that at the time of this disclosure I also told Mr. Holmes that I had this idea but that I didn't have any means to carry it into execution.

In the present case, I testified on page 1782 with regard to my disclosure to Mr. Holmes,

"And the back trap would be returned to the heating coil and the tar (residuum) would be drawn from the bottom of the vertical still or vertical drum that we were discussing."

2163 In the Anderson-Prichard case, I testified in direct examination as follows:

2165 "Q. Could you state, please, the substance of your conversation with Mr. Holmes in which you gave him this idea that you have just referred to as to your process, the coil and drum?

1392 "A. As I remember, we discussed the drum, I think Mr. Holmes brought the drum up as to be on this coil, anyway that was in discussion, we should have a coil and a drum; that is, not the reflux principle but to let the oil go into the drum, and be decomposed by its own heat and the effect of the heat. Now, I don't remember the exact words other than this suggestion of the drum, but I do think I disclosed to Mr. Holmes that we wanted to go further than that, that is, we wanted to get this reflux that was causing the trouble, that is on the Redwood, returned back through the coil where we could wear it out. And, of course, I didn't know how to do that,
2166 or I wasn't sure that we could take that up, but the general idea to bring the backtrap back to the coil and wear it out, and Mr. Holmes had already suggested the drum.

* * * * *

"Q. Yes, sir?

"A. I should think it would have been—and his process was a continuous, as Mr. Holmes suggested, was a coil and drum continuous process, that is, that
2167 was his idea; and mine, I suggested this other, which I should think would be a disclosure.

"Q. And that other was what?

"A. The return of the reflux back to the charge through the coil.

"Q. In this discussion did you make any reference to the residuum?

"A. I am saying Mr. Holmes' process that he suggested was drawing the residuum; I don't remember exactly what his idea was except it was continuous, and it was to take vapors over the top and just take a light percentage of cracking more like viscosity breaking.

"Q. In this process idea which you had, which you talked about to Mr. Holmes at that time, was any discussion had of what you were to do with the residuum that was created in the process?

"A. As I remember it, I am giving you about all that we discussed, he wanted the drum.

"Q. But you discussed the question of residuum, didn't you?

1393 "A. I don't think so.

"Q. You didn't?

"A. No, I don't think so."

• • • • •

"The Witness: There is a little confusion in the answer because there was a heat treating process
2169 which was continuous, and the heat distilling process and in the first part of our conversation, as I remember, we were talking about this high pressure coil and how to utilize the heat, which was a continuous process. Then if you read it in that light, that I made the suggestion of putting in a distilling process in which we returned the reflux, you have the idea that I endeavored to convey."

In the present case, on direct examination, page 1781, I testified with reference to my disclosure to Mr. Holmes, as follows:

"Well, after we discussed this phase of the proposition, I told him that I thought there was only one way to make gasoline and that was a continuous distillation process."

2170 In the Anderson-Prichard case I testified as follows:

"Q. Yes, sir.

"A. I should think it would have been—and his process was a continuous, as Mr. Holmes suggested

was a coil and drum continuous process, that is, that was his idea; and mine, I suggested this other, which I should think would be a disclosure.

"Q. And that other was what?

"A. The return of the reflux back to the charge through the coil."

I also made a disclosure of my scheme to Mr. Detweiler:

2171 "Q. When you made that disclosure to Mr. Detweiler, isn't it a fact that you told him that you merely had this idea but no means to carry it out?

"A. I am not absolutely sure unless I would know the exact time that I disclosed it to him.

1394 "Q. Well, now, what is your recollection?

"A. Well, he didn't come to The Texas Company until, I think, August of that year, and it had been shortly after he took charge of the research department there.

"Q. Did you disclose it to him or did you not? That is, did you tell him that you had no means for carrying out this process?

"A. Well, if I disclosed it to him—here is my point: I don't remember the time or don't remember the incident, excepting I remember I disclosed the process, but I don't believe my memory is good enough to fix that.

"Q. You don't know.

"A. I had better say I don't know."

2172 At the time I saw Mr. Smith of The Texas Company, I had this idea without any means of carrying it out. Mr. Smith suggested a jet pump and prepared a drawing, DX 667, illustrating my scheme with a jet pump for returning the backtrap. This drawing was brough to me and I made some pencil changes. DX
2173 667 has no description of the operation of the proc-
2174 ess. The apparatus there shown could be used for simple distillation or could be operated under a vacuum, or even in the vapor phase.

2175 Runs on Experiment 8: Equipment for Experi-
2176 ment 8 was not ready until May 25, 1917, after which four runs were made on gas oil charge. These runs did not exceed a total of one week's operation spread
2178 over a period of two or three months. The feed rate on Runs 6 and 9 of Experiment 8 was 25 or 30 gal-

lons an hour. On runs 7 and 8, it was about 42 gal-
2179 lons an hour.

Finally two kerosene runs, which consumed a few additional days, were made. The equipment of Experiment 8 was finally dismantled.

2180 1395 Run 6, which was the first run made with the little experimental device called Experiment 8, made a gasoline yield of about 16.66%. This was re-
2181 ported to The Texas Company. This figure of 16.66% should be somewhat higher, not more than 3% be-
2182 cause of evaporation losses and samples. The run was approximately 50 hours.

2183 Run 7 had a running period of about nineteen hours.
2184 Carbon deposited along the bottom of the tubes.

"Q. As I understand your testimony, in that run and other gas oil runs with this little experimental apparatus, there was a segregation of your oil as it went through your tubes? The liquid oil would be along the bottom of the tubes and the vapors would be above the liquid oil going through the tubes? That was your understanding, is that correct?

"A. That was my theory, that the velocity in this
2185 coil was not sufficient to keep the oil in agitation to overcome the overheating of the residual oil flowing along the tube.

"Q. These carbon troubles that you got in the operations with gas oil, with this experimental plant 8, you ascribe to that condition existing in your tubes?

"A. The two conditions. You understand on 6 and 9 the carbon was not bad, but on 7 and 8 when we didn't have air condenser enough and the stuff distilled out at the top we had a worse condition. That is, the lighter the oil and the more of it you get back the better it will be for your tubes.

"Q. But one of the conditions we have been talking about which you say or you feel resulted in the formation of this carbon in the tubes of your Experiment 8 was this segregation of your liquid oil with your vapors above the liquid oil in the tubes, isn't that correct?

"A. That was my theory, but of course no one knew the condition in those tubes. That was my theory."

2187 1396 In the experimental device, plant 8, tube and

drum, the heating coil was two hundred thirty feet long and three inches inside diameter.

2188 I vouch for the accuracy of a summary report from Mr. Detwiler to Mr. Manley, which is PX 7 in this case.

2189 The carbon catcher referred to in the report was to catch residuum and whatever carbon was formed which could be drawn off at least partially with the tar.

Residuum from the cracking operation contains asphaltic bodies or asphaltenes which are high boiling
2190 liquids which rapidly go to coke on further heating. The only way these asphaltenes could be separated from the residuum would be to remove the residuum from the still and then distill the residuum.

2192 An accurate statement of what occurred during Run 6 is contained in Detwiler's report, as follows:

"The run was discontinued because of leakage.

"The valve in the tar line, and the union on vapor line next to water box were leaking very much during the entire run.

"The head on manhole, to large drum, would flash whenever the pressure was maintained, much above 200 pounds.

"Only the lower tubes were carbonized and these contained a thin scale on the bottom. The drum contained little or no carbon."

Run 7 was correctly reported as follows:

"The run was discontinued because of excess leakage around the copper gasket in head to drum and around the riveted joint of manhole on drum.

"The two lower tubes contained considerable carbon on bottom of tubes."

Run 8 ran 29¾ hours and made a yield of 21.71 percent gasoline. The following remarks are all taken
2191 from the report and are accurate with regard to Run 8:

1397 "The run was discontinued on account of leakage.

2193 "You will note that on all of these runs considerable trouble was experienced on account of leakage. The apparatus is now undergoing repairs and we hope to have it in such shape before making the next run that a closing down will not be necessary, due to the leakage as has heretofore been the case."

2194 Run 9 was the final run with gas oil charge on this experimental apparatus, plant 8, and produced about 18½ per cent gasoline yield with an over-all running time of 54½ hours. The producing time would be about eight hours less than the over-all time.

Runs 6, 7 and 8 also had a producing time of approximately eight hours less than the time previously stated.

2195 The following quotation from PX 8 is a correct statement with regard to Run 9:

"This experiment, as previous experiments with Paraffine Base Gas Oil as stock, demonstrates that the lower tubes carbonize considerably and the run, consequently, is of short duration."

2196 The statement above applies to all the runs. In Runs 6 and 9, we didn't get much carbon and made
2197 over twenty-one percent gasoline which at that time in my mind would have been considered a very good yield. What I wanted was a long run without getting any carbon in the coil, if possible. I also wrote the following remarks with regard to Experiment 8:

"This difficulty with Paraffine Base Gas Oil can probably be very much overcome; first by lengthening the tubes so that it will not be necessary to carry such a high temperature in the furnace, and secondly, by increasing the velocity of oil and vapor through the
2198 tubes so that the carbon will be swept along with the oil and vapor in the tubes."

With the completion of Run 9, all the work I ever did on Experiment 8, tube and drum apparatus, with gas oil as a charging stock was ended. My next efforts with Experimental Plant 8 were made with
2199 kerosene as a charging stock. Two runs, Nos.
1398 10 and 11, were made as shown in PX 9 and 10.

Run 10 produced 13½ percent gasoline yield and Run 11 produced 14½ percent gasoline yield. I did not, as a result of these two runs, reach the conclusion that it was impossible to operate this experimental device for the cracking of kerosene. However, I wrote the following remarks, shown on PX 10, which are correct:

2200 "The object of the experiment was to try out this apparatus on kerosene, and ascertain whether the conditions of cracking could be obtained on this apparatus.

"The results are not very satisfactory because the conditions of rapid decomposition were never reached. Alterations and modifications will remedy this defect in the present apparatus for kerosene product."

2201 PX 9:

"This experiment, as Experiment 8, Run 10, demonstrates that it is impossible to reach the conditions of rapid decomposition in this apparatus. There must be more coil, more pressure and air condenser."

2201 After the two runs with kerosene charging stock were made on the Experimental apparatus, Experiment 8, tube and drum device, no runs were ever conducted with any kind of oil on this apparatus.

I would say that in the two final runs with kerosene charging stock (Runs 10 and 11) the kerosene was very largely vaporized in the heating coil, but I had no means of determining that. We had insufficient pressure to get the conditions or to hold it in a liquid

2202 state.

On unclean hands issue in this case, I testified (R. 1149) as follows:

"Q. Now, this statement that was made, that you made for The Texas Company was dictated by you on May 10, 11 and 12, of 1926, at Port Arthur, Texas, was it not?

1399 "A. This was not entirely dictated by me, we worked together.

"A. It was not entirely dictated by me, we assembled the facts, talked that over, and it was couched in words, sometimes by Mr. McCarthy, I think chiefly by Mr. McCarthy."

This testimony relates to the statement I made for The Texas Company in 1926 in the presence of Mr. Mace, patent counsel for The Texas Company, Mr. Donaldson and Mr. McCarthy. Mr. Mace has been in attendance at this trial during practically the entire time.

2203 The following is a quotation from the statement I made for The Texas Company in 1926, page 11:

"This carbon deposit on the bottom of the tubes

2204 was due, probably, to the stratification of the heavy residuum oil on the bottom of the tube and the vapors above, indicating that the velocity was not sufficient to thoroughly mix the oil and vapors."

The above has always been my theory and relates

to my experimental operation, plant 8, tube and drum device.

2205 In The Texas Company *vs.* Anderson-Prichard case, on cross-examination by Mr. Thiess, I testified as follows:

"Q. Yes, sir.

"A. We got much more cracking than we would like to have had in the coil because we didn't have the velocity and it looked like the oil was stratified in the lower rows of tubes.

"Q. What are you talking about?

"A. Experiment 8, coil and drum.

"Q. These are the experiments you are talking about?

"A. Yes, sir."

2206 I wrote a letter in 1921 to Mr. Dodge who was assistant superintendent of The Texas Com-
2207 1400 pany's Port Arthur plant which letter has a reference to Experiment 8, coil and drum apparatus. I stated as follows:

"The time of travel through the coil was too much and as a result the tubes carbonized too much on account of decomposition in the coil."

This has reference to the formation of carbon in the tubes of Plant 8, experimental device, tube and drum, and is an accurate statement of what occurred.

2208 In this letter, I also stated with respect to other experiments which I wished to conduct:

"To determine whether there is any possible method of operating a coil so as to obtain appreciable cracking therein without carbonizing the tubes. Our experiments so far indicate it cannot be done."

The foregoing is a correct statement.

2209 Proposed Pilot Plant: Following the discontinuance of Plant 8, tube and drum experiment, I desired to build and operate a larger still known as a pilot plant or semi-commercial plant for the purpose of finding out whether I could overcome the infirmities and de-
2210 fects I found to exist in Experiment 8 tube and drum apparatus. The pilot plant was never built. DX 686 is a drawing of a proposed pilot plant. Certain pencil notations were made on the drawing by Mr. Bailey
2211 at my suggestion. The word next to the pencil notation "10 feet" might be "Maxim" meaning maximum.
2212 DX 693 is a drawing which was supposed to in-

2213 corporate the changes made on DX 686 on this
2214-16 drawing. The partial condenser is about ten feet above the inlet to the heating coil. The draftsmen departed from my instructions by omitting the jet pump in the drawing DX 693.

1401 In direct examination, I stated that the pilot or semi-commercial plant shown in DX 686 was not built because satisfactory elbows or return bends for the tubes could not be obtained.

In the letter which I wrote to Mr. Dodge in 1921 with reference to the proposed pilot plant shown in DX 686, I stated as follows:

"Proposed high pressure. This was an improved equipment to continue the experiments initiated with the coil and drum. Bailey drew up the apparatus—see blueprint from tracing Y-2200, and estimates were made on the still by Kellogg Company, but for some reason unknown to me, the building of the equipment was dropped."

The statement made in the letter was a true statement when I made it.

2217 In the statement I made to The Texas Company some fourteen years ago with reference to the same pilot plant, DX 686, I said as follows:

"I took the matter up with Mr. A. S. Bailey, who wanted the approval of higher authorities before he proceeded to build the apparatus. Apparently he had obtained this authority because he took up with various manufacturers the question of materials for the equipment, but for some reason unknown to me this equipment was not built at that time."

2218 It is not a fact that I did not build the proposed pilot plant because I had no satisfactory means of returning the backtrap to the heating coil.

In the Anderson-Prichard case, I testified as
1402 follows with regard to the proposed building of this same pilot plant:

"Q. Can you state whether or not at that time you were able to build a heating coil of the kind that you wished to be installed in this semi-commercial unit about which these various drawings and letters were passed?

"A. I was not.

"Q. What were the reasons for that?

"A. The engineering department had been unable to obtain material to construct the heating coil and they had no information on a suitable pump of any kind.

"Q. To do what?

"A. To return the backtrap to the preheater coil inlet.

"Q. Do you know whether or no. the engineering department had made any effort to locate such a pump?

"A. They had made very extensive efforts."

It was the total equipment which they could not build—pressure coil, pump and fittings.

One of the reasons I didn't build the proposed pilot plant was because I didn't have any suitable means to return the reflux to the heating coil. As shown by
2220 DX 686, the heating coil of the proposed pilot plant is fifteen hundred feet long and two inches in diameter. I calculate the charge to be 12½ barrels per hour.

2221 I wanted a higher velocity in the coil to heat the oil uniformly without carbon formation. In Experiment 8, tube and drum, "we found—it stratified, it looked like." Along the bottom of the tube, the heavier residue was baked and stewed like you would in a frying pan and coked along the bottom.

1403 The high velocity was to cause the mixing of the heavier oil and prevent local overheating, and it may even be possible to not get carbon at all. If carbon formed it would be blown out; it would be carried along with the vapors out into the drum.

2222 Experiment 18, Battery 3: The next scheme in which I attempted to carry out this idea of clean circulation was on Experiment 18, Battery 3.

Some runs were made on Battery 3 before any attempt was made to return the backtrap to the heating coil. We put the preheater coil on just as soon as
2223 we could find one even for that low pressure. The first run with the preheating coil was No. 5. All previous runs were without the preheating coil. In February 1919, I attempted on Run 8, Experiment 18, Battery 3, to return backtrap to the heating coil by means of a jet. Only one run was made and it was
2224 found not to be successful. The jet was removed after this one run. Battery 3 was never thereafter operated

again when we attempted to return reflux or backtrap to the heating coil.

Experiment 18, Batteries 1 and 2: Experiment 18 also embodied Batteries 1 and 2. These batteries each had two large vertical drums in series, holding over two hundred barrels of oil.

2225 The three batteries cost over $200,000.00.

In the operation of all three of the batteries of Experiment 18, save for one unsuccessful attempt to return reflux through the heating coil in Battery 3, the reflux was returned in all cases to the large stills

2226 1404 where it mixed with the residual oil. This operation is not "clean circulation."

Experiment 18, Battery 4.

After I abandoned the use of the jet following the one unsuccessful run with it on Experiment 18, Battery 3, I conducted another experiment known as Experiment 18, Battery 4. This was a large scale equipment consisting of four big drums in series, each holding one hundred barrels of oil, with a preheating coil communicating with the first drum in the series. Battery 4 started about April and continued until the end of December 1919. Throughout this entire

2227 period, backtrap was always returned to the drum where it mixed with the residual oil. This is not "clean circulation."

Mr. Holmes asked me to come to New York for a conference about the middle of October 1917. He was kept fully advised as to my experimental work, Experiment 8, coil and drum. He also knew of the proposal to erect the semi-commercial or pilot plant to determine whether I could overcome the defects that had manifested themselves in Experiment 8,

2228 tube and drum apparatus. He would have made the final decision not to build this proposed experimental pilot plant if that decision had been made.

At the New York conference, Holmes told me that

2229 we had to get to making gasoline commercially and it was then decided to build what the engineering department could build and they couldn't build above 200 pounds pressure. We built the large scale experiments known as Experiment 18, Batteries 1 to 4 inclusive.

After Experiment 18, Batteries 1 to 4 was built, twenty-four commercial stills were built of practically

the same size as those in Experiment 18. The
1405 throughput of each commercial still was at least sixty barrels an hour. The cost of each battery was about $250,000.00. The total cost would be twenty-four times that or $6,000,000.00.

2230 In all these twenty-four commercial stills, reflux was returned to the large chambers or retorts and
2231 there mixed with the residual oil. Operation of the commercial stills in that manner began in March of 1920 and continued until the summer or early fall of 1921.

2232 Experiment 11-B Reconstructed.

The only other attempt I ever made, throughout my experimental activities at The Texas Company, to return backtrap to the heating coil was Experiment 11-B reconstructed. The big function of that experiment was to find the best type of pump to return reflux to the coil. The first run was made in March or April of 1919 and the experiment continued with different devices until 1922. Then it was continued up until 1923.

2233 Experiment 11-B was supposed to be a small model of the commercial still and consisted of four twelve inch pipe still about 16 feet 6 inches in length and provided with air condensers and scrappers, tar lines
2234 and charging lines, etc. Approximately four to six barrels of oil per hour could be charged. We found carbon would stick to the sides of these twelve inch drums or tubes, so scrapers were installed to keep
2235 the surface clean and did keep the carbon down to a thin layer. These scrapers did not do what we would like to have them do. Several types of scrapers were tried on Experiment 18. The first commercial still had scrapers installed.

2236 A jet was first used in Experiment 11-B in
1406 March of 1920 in an effort to return reflux to
2237 the heating coil. The coil had a total length of about 300 feet and was made of two-inch diameter tubing. The apparatus was so set up that reflux
2238 from the partial condenser could flow into the retort as well as into the coil. We did not know how much reflux was returned to the heating coil. We did not feel our calculations were accurate enough to know how much was being returned.

2239 Save for the use of a jet in 1925, I never again used the jet for returning reflux to the heating coil.

2240 The Texas Company installed a jet and operated it in a commercial plant in 1925 when it was facing litigation involved in the interference with the Dubbs patent. I knew that Dubbs was attacking the operativeness of the jet as shown in my application.

2241 The equipment which had the jet in the year 1925 also had a high pressure booster pump to put more pressure on the jet. My Experiment 8 and the ap-
2242 plication which I filed in the Patent Office did not show a high pressure booster pump. In Experiment 8 we did not need it. In addition, the commercial operations with the jet in 1925 or '26 made for the purpose of litigation, had the reflux fed into the coil at a point intermediate its inner and outer ends
2243 so that the friction pressure would be reduced. The friction pressure would have been much higher if the reflux had been returned to the inlet of the cracking coil. Three batteries in 1925 were equipped with the jet, booster pump and coil. At that time, about one hundred batteries were operating without the jet. The jet batteries were still running in 1927 when I left.

2244 1407 Summarizing: Prior to 1921, when the commercial operations started, I conducted but three operations in which I attempted to return reflux to the heating coil. The first was Experiment 8, tube and drum, where I used a jet. The next was Experiment 18, Battery 3, and there the jet was used for one run and found to be unsuccessful. The last attempt to return reflux was made in the recon-
2245 structed experimental device 11-B. A jet and other devices were there used until we discovered the surge pump. Various pumps were tried and the only one which I am sure would have been a success was a double acting plunger pump, a test of which was made in February 1921.

From my conception in 1916 up to February 1921, the actual use of a jet was confined to three experiments in which it was utilized in an attempt to return the reflux to the heating coil. When I filed original application for patent, serial number 263,562, on

November 21, 1918, I intended to incorporate and did incorporate in that application this experiment
2246 8 coil and drum set-up which I say I operated in the summer of 1917. The application was based on that set-up.

When I filed the application in 1918, I did not know of any satisfactory means for returning reflux to the heating coil, that would operate on a still of
2247 practical size. It was not until sometime in 1921 that I first found a satisfactory means for returning reflux to the cracking coil in a commercial operation.

1408 In the Anderson-Prichard case, on page 532, I testified as follows:

"Q. Do I understand this jet pump was not workable on the larger equipment?"

"A. That is right. The trouble—that is, so far as we were able to make one, that is, as we went up, decreased the temperature of the tube and increased the flow of oil through it, the tube pressure drop increased. We could in the shop make one up to handle three or four or five pounds, that would have been no problem, but when we went over that we didn't know how, that is so far as we knew in the plant there we didn't feel we knew how to do the job and hte jet pump was 'out,' for the high pressure at a high pressure through the coil and no one knew of a plunger type pump or centrifugal pump or other type pump that they would recommend, any of the manufacturers."

2249 The coil in each of batteries 1, 2 and 3 of Experiment 18 was two inches in inside diameter and about fifteen hundred feet in length. In the one experiment I made in this apparatus with the jet pump the reflux would be required to travel through the entire fifteen hundred feet of coil.

2250 After Experiment 8, coil and drum, had been completed two experimental devices were built and tested by me which did not embody "clean circula-
2251 tion." Experiments were conducted on Experimental apparatus 11-A from the fall of 1917 until the spring of 1918. Still 11-A had scrapers and did not embody the principles of clean circulation.

1409 ***Redirect Examination by Mr. Thiess.***

2254 I have looked through what records I have, and
2255 to the best of my recollection we made just one run on the Dewar & Redwood still to determine the effect of pressure after my work on experiment No. 8. We had been running the condenser coil under pressure and we ran the condenser coil at atmospheric pressure to determine the effect of that operation and compare it with the previous run.

2256 I experimented with the Holmes vertical stills without returning reflux to the inlet of the coils in experiment 11-A, experiment 11-B, and experiment 18, the large stills.

2258 Referring to DX734 (under the rule) which is a photostatic copy of the statement which was used
2259 in my cross-examination and which I made at the time that I was with The Texas Company, the second complete paragraph on page 22 of this document, reads as follows:

"The above outline of the experimental work conducted under my supervision is from my unrefreshed recollection and will be checked up and revised as found necessary after further consideration."

2275 We didn't conduct any further experiments on the apparatus of the coil and drum experiment No. 8 because we were unable to reach the pressure and temperature and operating conditions to obtain what we considered to be a fast, satisfactory rate of cracking, and the equipment was ill-proportioned. For instance, the coil, the diameter of the coil and the length was such that the rate of flow through the tubes would not give sufficient velocity to keep
2275 1410 the tubes clean. The air condensers were too small, and whenever we would—at 300 pounds and 750 degrees in the drum, it just wouldn't stand the pressure.

The next logical step, was to get an apparatus more nearly proportioned correctly and of a larger size so as to cut off the radiation loss so that we could maintain the proper temperature in the drum. We needed more pressure, more velocity and more coil and more air condenser.

The practical information that we got from these runs that I conducted on experiment 8 apparatus was
2276 that we made a good gasoline. It showed that we could make a good product, a suitable commercial product, at a fairly rapid rate. It gave us the information that we could go ahead and design an apparatus with the proper proportions and at least get started into the engineering difficulties of building a high pressure equipment. And as the result of these things I drew up a sketch and turned it over to the engineering department to start this
2277 program of improvement.

On cross-examination I said I knew of no practical means to return reflux to the coil when I filed my application. It was my idea at that time that it would require considerable pressure through the coil in
2279 order to get the desired velocity. We wanted high velocity through the coil and projecting it to commercial equipment, we knew there would be a large volume of oil, and to get the velocity we would have a high back pressure and resistance of the flow of the oil and vapors, through the coil. And I knew of no device at that time that would pick up this hot backtrap and return it to the coil.

2279 1411 In cross-examination I was referred to a letter to Mr. Dodge and a statement was read to
2280 me from page 5 of the letter. The statement that was read to me refers to a process in which we had intended to do all or practically all the cracking in the coil. We later proposed equipment for it and I subsequently filed a patent application on that, and Behimer patent No. 1,923,526 (DX 744) was issued.

The statement to me from the Dodge letter (DX 745 under the rule) and the next few paragraphs, read as follows:

"It seems to me much more advisable to build a coil for the Marsh Pumps and, for that reason, the following blueprints from tracing No's. have been en-
2281 closed. The apparatus is designed so that it may be used for the following experiments by making slight modifications:

"(1) To determine whether there is any possible method of operating a coil so as to obtain appreciable

cracking therein without carbonizing the tubes. Our experiments so far indicate it cannot be done."

That is as far as it was read to me. The letter continues:

"The commercial success of this proposition depends upon the extent of cracking that can take place in the coil without carbonizing of the tubes. If 10% of the charge can be cracked in the coil to gasoline products without carbonizing the tubes, it has some possibilities; with less extent of cracking it has no chance and with greater extent of cracking the possibilities are very good. The method of determining this point will be to time the rate of charge through the coil, so that 10% will be cracked into gasoline at the coil outlet. The oil will be discharged from the coil outlet into a separating drum, where the asphaltic and polymer products will be drawn off as fuel oil,
2282 road oil, etc., from the bottom and the vapors will pass over the top into a fractionating tower where the heavy distillate will be separated from the naphtha. The naphtha will go over the top of fractionating tower to water box; the heavy distillate will be drawn off the bottom of fractionating tower and recirculated with the charge through the preheater.

1412 "If this extent of cracking can be obtained, this will make a very neat process. There will be 2% of the charge drawn off the separating drum, as liquid fuel. 10% of the charge over the top of fractionating tower as naphtha and about 88% of backtrap from the bottom of fractionating tower continuously being recirculated through the preheater. It will cut out the rerunning of pressure bottoms, for the coke forming oils will be separated in the separating drum.

"The fuel consumption will depend upon the per cent of backtrap to be circulated through the coil. The greater the extent of cracking in the coil the less the backtrap and the less the fuel consumption."

2283 In the coil and drum operation No. 8, we weren't particularly concerned about where the oil cracked, but we thought a considerable portion of it would take place in the drum. Our major consideration there was to keep the coil clean, keep it free from carbon.

In the operation of the commercial batteries, they

had a regular pump house and there was a charging line main that ran behind the batteries so that a charging line dropped directly off of the charging main to the commercial battery. The pressure on the charging main was not sufficient to operate the jet
2284 pump, and in order to get a sufficient pressure to operate the jet pump a booster pump was inserted between the charging main and the jet pump.
2285 I was cross-examined with respect to the per cent of gasoline on the charge in the runs of experiment 8 given in the Detwiler reports. The yields as there given were for the entire period, but in the bringing
2286 up period there was merely fresh oil going through the system. It isn't being cracked much, and when you distribute the yield over the total charge to the system it looks considerably smaller than what
1413 you are actually making under operating conditions, if you calculate the basis of the charge under operating conditions. On the onstream period the yields would be much higher than it is where you are distributing it over the charge from beginning to end of the run.

In cross-examination I was interrogated with respect to battery 3 and the use of a jet pump to return the reflux, and referred to it as an unsuccessful
2287 attempt. I meant by "unsuccessful" that all of the backtrap was not returned. About 25 per cent, as I calculated at that time, returned through the heating coil.
2403 Plaintiff's counsel read two excerpts from the Anderson-Prichard testimony, one from page 531 which ended on page 532, and then another one beginning at the bottom of page 532. The testimony in between, on 532, reads as follows:

"Q. Do you know what kind of pumps and what types of pumps they had investigated as a possibility for this purpose

2404 "A. They had investigated, I believe Mr. Bailey at least suggested an idea of a centrifugal pump, as I remember, but he did not get any information that was material to getting something to put on.

"Q. Did you personally make any efforts to find a pump that would do this job about this time?

"A. It seems to me like I wrote some company about a pump.

"Q. Did you have any contact with the engineering department in this connection; that is, towards getting a pump to do this work?

"A. I was in contact with them continuously and was counting on them to give me a great deal of assistance and I think they were making every effort they could to obtain it. They were taking it up with the salesmen of pumps and manufacturers but they had not been able to find one even to attempt to furnish a U-bend or pump or anything to do this work at the high pressure and the high temperature."

2408 1414 My statement to The Texas Company made in 1926 reads in part:

"In conducting these experiments I at first used a small bomb and about January, 1916, I started experimenting on an apparatus modeled after the Redwood patent. I believe Dr. Gray outlined the experiments on all this apparatus before I came with the Company.

"The first run on the Redwood apparatus was made with gas oil but this did not decompose very rapidly so they changed the stock. Later the Redwood equipment was modified by lowering the brick work so as to cover the upper half of the still and also the air condenser was arranged vertically instead of horizontally. The chief result of this change was in the character of the product. The heat reaction was reduced from above 100 to about 50 or 60 degrees. Also on account of this change the accumu-
2409 lation of kerosene fractions was more noticeable than in the original Redwood design, especially on Run 12 of this apparatus, and about this time came the conception of returning or backstrapping the kerosene accumulation to the front of the still, so that it would pass through the entire length of the heated still.

"After the first experiments on the Redwood apparatus a few runs were made upon a coil, which runs demonstrated that the coil could not be operated for any length of time on account of carbonization in the tubes. This equipment was not designed by me but I was aware of its numerous defects be-

fore the apparatus was installed, and I suggested to the Engineer Keokkeok at the time it was being built and also later, I believe, to Mr. Holmes and Mr. Manley, that the system could be greatly improved by adding a drum in order to utilize the heat of the oil to continue the decomposition in the drum, instead of running the heated oil directly from the coil out-
2410 let into a condenser coil. This equipment was abandoned because of mechanical inconveniences and the carbonizing of the coil.

"About the time I noted the accumulation of kerosene fractions to the front of the still on Run No. 12 February 1916, of the Redwood apparatus, I was trying to work out a theory of how to make a practical operating equipment and drew up a sketch at the time, but I was not able to get a design or method that looked feasible. This sketch consisted of a vertical drum connected, outside a furnace, to a heated 12 inch horizontal pipe, similar to the equipment of Experiment No. 6. There was a vapor outlet from the pipe to the drum, near the top, and a liquid connection near the bottom. From the top of the drum the vapors went to an air condenser where the heavy kerosene or backtrap fractions were sep-
2410 1415 arated from the naphtha and returned to the front of the pipe or still. The charge entered at the same point as the backtrap at the front of the still. This design was abandoned as not practical. No blue-print of this sketch was made, nor was anything further done along these lines because I came to the conclusion that the only practical way of pre-
2411 heating the backtrap would be to confine it in a coil, together with the charge so that it could be introduced into the bottom of a drum or still. The object was to get a volume of oil and at the same time maintain the temperature of the oil without subjecting it to the dangers of high furnace temperatures. It was known at that time that the tensile strength of iron would have to be considered in connection with high furnace temperatures and it was also known that an accumulation of carbon in the still would cause the still wall temperature to become the still furnace temperature when the still wall became coated with a thick coat of carbon. I also knew at that time

cracking could not be carried on extensively for any length of time in a coil without carbonizing and burning of the tubes.

"Now the problem was how to protect the coil and how to maintain the temperature in the drum without subjecting it to intensive furnace gases so the idea came of circulating the backtrap through the coil, together with the charge so as to increase the velocity in the tube to overcome carbonization and to carry such a temperature that it would not carbonize, utilizing the heat in both the backtrap and the charge for holding up the temperature in the drum and also the additional advantage of cutting of the cooling caused by the vaporization of the backtrap, if returned directly to the still.

2412

"At this time there were four problems to be solved:

"1. How to construct a still to withstand high pressure and temperature;

"2. How to build the coil;

"3. How to force the backtrap to the coil, and for the design and construction of the complete apparatus to carry out my scheme.

"It was not known to what extent the heat in the drum could be maintained by the charge and backtrap heated in the coil. It was knowwn that the temperature in the drum would be somewhat lowered but I hoped that the temperature in the drum would be high enough so that we would not have any outside heating.

"The idea of this arrangement was turned over to a draftsman named Smith in the fall of 1916 and it was conceived by me sometime between the time it was turned over to Smith and the noting of the accumulation of kerosene fractions on Run 12 of the Redwood apparatus. To the best of my present recollection the date of the conception of this idea was about the first of August, 1916."

2412 1416

2413

1417 *Recross Examination by Mr. Thomas.*

2288 In Experiment 18, Battery 3, 75 percent of the backtrap flowed back into the large still and therein was mixed with the residual oil in the still. The back

trap flowed from the heavy aerial condenser down into the top of the still.

2289 The booster pump that I referred to was used in 1925. We had a pump to feed the oil and then we
2290 used the high pressure booster pump and the jet. I do not believe that Schutte & Koerting Company suggested the 1925 set-up. I believe all they advised was the jet pump. Schutte & Koerting Company recommended a certain amount of pressure for the jet and The Texas Company got the pump. I have forgotten what pressure the Schutte & Koerting Company advised, but I believe the pressure was over a thousand pounds.

1418 RALPH C. HOLMES, Shingle House, Pennsylvania:

Direct Examination by Mr. Theiss.

2812 I am a farmer at the present time. About 1915
2813 and '16 I was vice president of The Texas Company, in charge of manufacturing, located at Houston, Texas. I was moved to New York in March or April, 1917. I remained vice president in charge of manufacturing until 1926. After that I was president. In 1916 and '17, I was the manager and directing head
2814 of all of the refining department activities including construction and operation. That covered all the work being done at Port Arthur, and the development work and research work was under my direction.

2815 As of 1915 only the Burton process was used commercially for cracking. We knew generally of the character of the process which was what we termed a batch process at that time carried on in individual
2816 shell type stills. The product that we knew of first was a heavy product, I think you would term it motor spirits of around 50-51 gravity and something over 450 end point. We secured samples and made our own analysis. And then in one way and another after they began licensing we learned generally of the operation.

The Texas Company did not employ any cracking processes about that time, 1914 or '15, commercially.

The method used by The Texas Company commercially at that time to produce gasoline was a distill-
2817 ing process, not a cracking process, but all of our operations were, and our facilities for crude distillation were, a continuous type in which we charged continuously and we withdrew the residuum. In a
2817 1419 battery we usually had six to eight stills, stepping up about six or eight inches one above the other so we had a flow from the initial still where we pumped in the crude to the last one where we withdrew the residuum. There was a constant charging and constant flow of vapors from each still through separate condensers, and fractionating towers, and a constant withdrawal of residuum and an exchange of heat, taking the heat from the residuum into the crude as being charged. Crude operations generally by others were of the batch type.

2818 About this time in 1914, or '15, we were desirous of getting a process to produce cracked gasoline. The principal reason was that the development of the automobile and the development of the electric light plants throughout the country had changed the percentage ratio of petroleum products. By 1916 the crude running was something like 300 million barrels, and the kerosene consumption was about the same as it was in 1903 and '04, and the gasoline requirement had increased from some 6 to 8 million barrels when we began refining to approximately 60
2819 million barrels by 1916. Our principal plants at that time were located in the South, Port Arthur and Port Neches, and we had a large production of South Texas crude in which there was a maximum of about two per cent of gasoline. It was very important for us, as it was with others, to increase the yield of gasoline from the crudes run.

The proposition of using the Burton process was
2820 considered by our people. I never was favorable to the idea. My judgment and advice was that we could and should develop a better process. I was very anxious and confident that we could develop a continuous process, one with the economies that go
2820 1420 with that sort of a process as against the batch process. We began our patent studies back in 1910 and 1911 and we began our investigation of the

possibilities at that time, and by this period 1915 and 1916, I was becoming more confident both of our ability to build up a satisfactory patent protection and a process; and the ultimate outcome was that we did develop our own process.

I know Mr. Otto Behimer. He made a demonstration for me of the Cross process of the Cross Brothers at Kansas City in 1915. Later he applied to Dr. Gray for employment with us and we had taken an option on the Cross process and it was agreeable to
2821 them for us to take him,—we employed him principally because we wanted to carry out this research and development work in connection with the Cross and other processes, and we felt that he was qualified to do some of that work.

We sent Mr. Behimer to Port Arthur. When he first went there, he carried on a series of experiments.

2823 I discussed with Mr. Behimer some ideas which he
2824 had with respect to a continuous cracking process in Port Arthur in early August, 1916. I had gone down there, and when I arrived they were making a run, the first run on a coil installation that I had directed be installed to make a continuous test of the Cross process, and Behimer was operating that with
2825 some assistants. The Cross process at that time was a method of treating crude under high pressure and producing what we called a synthetic crude. Then that crude was distilled in the ordinary way at atmospheric pressure and produced a gasoline as nat-
2824 ural crude would. And during the conversation
2824 1421 with him at that time, he disclosed to me his ideas of a continuoust operation differing from what I had in mind in this test. That is when he disclosed to me his idea of what we call the coil and drum with return of reflux oil to the coil.

2825 When I directed that the coil be set up, I had in mind that it would not only be a coil but there would be a drum in which a part of the so-called reaction would take place. They had had great trouble in getting any pressure equipment and they were operating this with no drum, just a coil, and I said to Behimer at that time that we should have a drum. He remarked promptly that he did not think we

ought to bother with that, he had an idea that we would not need to make this synthetic crude, which we were attempting to do with the Cross process. Behimer's idea was that they could operate at lower pressure, around three or four hundred pounds, and in his studies and research work during these months that he had been waiting for this coil.

2826 This is what he told me,—that during that period when he had been working with the small Burton installation and the Dewar and Redwood installation, that he had discovered there was an accumulation of what he termed kerosene fractions, they were in effect reflux fractions from running these gas oils with approximately a kerosene distillate. They were not a kerosene, but they had a similar distillation test. Those fractions, he said, were more difficult to crack and, when they were returned to the still, there was only a small amount of cracking, and that if they could be returned through a heating coil that they would serve two purposes, one was that they
2826 1422 would be more highly heated and cracks to a larger extent, and the other one was they would
2827 increase and accelerate the flow through the coil being an addition to the fresh charge.

He did not go into any great detail but I got a fairly distinct idea from him that he wanted a drum at the end of a coil, and a reflux condenser which would condense these heavier fractions of the vapors and that they should be returned through the coil with the charge—through the heating coil with the charge. At the same time he was charging continuously he would be withdrawing the residuum from the bottom of this drum and of course the gasoline vapors would be flowing continuously through a water box condenser and the drawoff condenser. It was a continuous operation, a continuous charging and a continuous withdrawal of the residuum and of the so-called naphtha or gasoline fractions. And it
2828 was soon after that I discussed that with Dr. Gray and Mr. Manley, and one or the other of them directed that he be given engineering assistance to carry out his idea of an experiment.

Drawings were made and material was ordered and the plant was set up and several runs were made.

2829 DX 669 is a print of the sketch that was made of what they call the coil and drum, and that was made for the Behimer experiment known as No. 8. I saw
2830 the apparatus itself after the runs had been made.
2832 I received reports respecting the work that was done on this coil and drum operation of which I have identified the drawing. DX 759 is a letter with enclosures under date of June 20, 1917, from Mr. Detweiler to Mr. Manley and covers runs 6, 7, and
2832 1423 8 of experiment No. 8. I got a copy of that
2833 letter and this is the copy I received. I also received copies of other reports by Mr. Behimer on this work and of letters written by Mr. Manley in respect thereof.

Mr. Manley was my first assistant, assistant manager of the refining department at that time. Mr.
2834 Detweiler was the chemist who at that time we had transferred from Bayonne to Port Arthur to take charge of the new research laboratory that we had built at that point.

2852 Testimony under the rule:

"Mr. Thiess: Q. What if anything did the reports of this apparatus and process that you received, demonstrate to you?

"A. First it conveyed full information in regard to the runs, as regards the charge, the character of the distillate and gasoline produced, the character of
2853 the residue, and so forth. It conveyed information to me of the yields which were better, so far as the gasoline production was concerned, than anything we knew of at the time commercially or experimentally or any other way. And also I knew that the product that we were charging was a much more difficult product to crack to produce gasoline from than was being used by those who were operating commercially under the Burton where they had a selected stock of a better character, more easily cracked. This stock we were charging contained a considerable percentage of actual kerosene. We were running to a minimum yield of kerosene of water white quality only, all the rest of it was second, third and fourth crude gasoline, that is in our distillate stock, in our cracking stock. We also had some of the South Texas distillates that were more difficult to crack than the par-

affin stock. So when I got these and considered them, I considered that we had a demonstration of cracking superior to anything we had known of at that time, as I say, either commercially or experimentally. That is what the report conveyed to me.

2854 1424 "I might add that I was responsible alone for the company's decisions as regards the processes that would be adopted or used. I had the final responsibility, which was a responsibility, of deciding these matters. I had to put them up to the Board but they were dependent upon me for my recommendations and as a rule adopted them."

End of testimony under the rule.

After the completion of these runs in August, July and August of 1917, we continued further experiments almost entirely for the purpose of developing a suitable or effective means of returning this reflux, forcing it back through the preheating coil in the system.

2855 That was the principal difficulty and only question in the problem in considering a commercial operation. That and also the difficulty of getting the coils and fittings, and so forth, that would withstand this pressure, pressure and heat.

2857 Before this coil and drum was set up, we had under consideration a continuous cracking distillation of some kind, and before these runs were made we had designed what we called a vertical still installation. I had made the original sketches in December 1916 and it was to be a continuous type of operation—a series of stills.

2858 Even before we designed these vertical shell-type stills, we had set up what we called the Wicks boiler-type. We had built a new steam boiler, which was a vertical boiler with a top and bottom heating and intermediate tubes which were fired. From that we got the idea of setting up a continuous operation and I think that was a series of six stills built just like the Wicks boiler, firing the tube section, the bottom

2858 1425 drum to catch the carbon, the upper one being long enough to admit men in there to clean the tubes, and run cleaners up and down through the tubes. Also that served as a vapor section. That we attempted to run continuously, but we had the same difficulty we had in all these things, we had the diffi-

culty of getting material that would withstand the pressures that we desired to operate under, and with the heats and so forth. We could not get material that would withstand the pressure and heats so that the leakage, and so forth, was excessive and it was the principal cause of the failure of those first continuous type stills.

2859 In December, 1916, the thought occurred to me that if we would use vertical shell-type stills and fire them —put them in a furnace with the bottom of the still some few feet below the floor of the furnace, and the top section above the roof of the furnace we could fire just the liquid surface, also put in a shell scraper and keep removing from the shell any excess deposit of carbon, so there would not be the trouble and danger that you would have in a horizontal still.

2860 About the middle of 1917 I had secured an appropriation for about $105,000, to put in one five-still unit in order to work out the furnace arrangements, heating arrangements and so forth in advance of a large installation of vertical stills which we contemplated.

It was during the war period, and the material was slow in arriving. Behimer and, I think, Mr. Hull,

2861 1426 our chief engineer, both thought it wiser, particularly Behimer, to break up this installation into smaller units and not put five stills in one unit, and I asked them to come to New York and confer with me before this installation was set up, which they did late in 1917, and we decided, Mr. Manley and Mr. Behimer and I, that we would set these up in three units. Unit Nos. 1 and 2 would be two stills each. Mr. Behimer was to have No. 3 in a one-still unit to continue his efforts with this return of the reflux to the heating coil. They were set up in that way.

We called that experiment No. 18, and we carried on a very large operation in those units during 1918 and 1919. It was during that operation that the coil was first fitted to this No. 3 unit and the reflux re-

2862 turned to the coil. Then there were smaller installations in the laboratory and research department of a similar character carried on at the same time and afterwards. I saw these stills of experiment 18 and on one occasion I ran them for three days.

"Mr. Thomas: Experiment 18, battery 3, with the

return of reflux to the heating coil, did you see that operate that way?

2863 "The Witness: I don't remember that in particular."

2864 During the war period, it was very difficult to get high pressure pipe of any character. These factories
2865 and mills making the seamless tubing were engaged almost entirely in making war requirements, a good many of them were making material for guns, and nothing that was not considered by the Priorities Committee as an absolute necessity was permitted to be shipped by them for anything but war purposes. It was almost impossible and we were all, those at Port Arthur and through my office, working almost constantly trying to get these materials, and the
2865 1427 only reason we got the pressure stills, these vertical stills, was because we represented that we would make a very considerable increased yield of gasoline, and we finally did get them.

2867 During the war I was first a member of the subcommittee of the Petroleum Oil Board, which was the Western Section, of which Mr. Cosden was chairman. I was on that board during the entire war. Later I was chairman of a committee of the Petroleum Oil Board which allocated to the refineries the amounts of gasoline that they should furnish for war purposes, and as a consequence of that I was on the Priorities Committee for refinery materials and tin plate, in order that those refineries that were to make these special gasolines would get the materials with which to do it.

2868 I received a copy of DX 708, which refers to a run
2869 on battery 3, experiment 18, previously described,

2870 We later took the best four of the stills of experiment 18 and set them up in a battery of four, and we took that preheater and added another one of the same capacity. We called that battery 4 and was operated with the preheater until about the end of 1919
2871 in a very large way. During the time that this battery
2872 of four stills was operating, Mr. Behimer came to New York and contacted me there, and while in New York he advised me that he had been in contact with a representative of the Hancock Inspirator Company in an effort to get a satisfactory pump and asked me if

I thought it would be well for him to go to the factory in Boston. I agreed with him that it would, and he went up there to contact those people at their
2872 1428 factory and was unable at the time to find what he thought would be effective in forcing this reflux back in a large operation such as we had at that time on this battery No. 4.

2873 I myself contacted no manufacturers directly. I was urging our people, through Mr. Manley and engineers, to do everything they could to try and work out that problem.

I had a copy of the report DX 711. This report is dated April 26, 1919. At the time of the receipt of this
2874 report (DX 711) April 26th, 1919, we were building the first six units of commercial cracking equipment. We had secured appropriation in 1918, a little over half a million dollars, for the first six units, and those were under construction. The appropriation for the next eighteen units of the first twenty-four, which was our complete installation at that time, was granted a little later, in August of 1919, but those first six stills were under way and were in operation. The first ones were put in operation in February, 1920. That was the condition of the larger permanent installation at that time.

2875 Those were known as the Holmes-Manley vertical stills, the vertical still installations.

2876 The last statement made by Behimer in DX 711 was as follows:

"Method 2 is in my opinion the best method of all;
2877 at present the jet pump has not been worked out. It will require some experimenting with a 3-inch coil and jet pump before it will be ready, for that reason it seems to me it is advisable to plan space in the new equipment for two 3-inch preheaters with each battery of 4 stills, then when the jet pump is developed it can be easily installed."

To follow Behimer's recommendation, at first these
2878 permanent vertical still installations were so
2878 1429 constructed and arranged that when the reflux pump was so developed to force oil through these preheaters, it was a simple matter of attaching them to this equipment as constructed. In the meantime we went ahead with a small four-still battery and tried

out a number of different kinds of pumps for refluxing back to a battery of four smaller stills. On the large installation it was simply a matter, when the pump was worked out, of attaching it; we put in the
2879 preheaters and they were large enough to care for the reflux when we were able to force it through. We had a continuous operation with continuous charge, the continuous withdrawal of the residuum, the continuous flow of the vapors, the continuous refluxing, but in the meantime the refluxing was returned to the stills, directly to the stills instead of through coil.
2881 To apply this Behimer process to this operation, the one thing that was missing was the pump with the ability and capacity to force this reflux back through this long preheater which was some 3600 feet long, of 4-inch pipe, and on which there was a very considerable back pressure.
2882 The first of the twenty-four units in which we returned the backtrap to the bottom of the still was put in operation in February, 1920, and the entire installation of twenty-four batteries was completed during 1921.

I was familiar with this operation thoroughly by re-
2883 ports and occasionally by observation.

1430 "Q. What were the commercial results in operating this installation?

"A. The commercial results were very satisfactory as to yields.

"Mr. Reichmann: That calls for a conclusion. That is too broad a question and I object to it.

"The Court: It is too broad. That question is altogether too broad. Objection sustained.

"Mr. Thiess: Q. Were the operations of these units satisfactory from a commercial standpoint?

"Mr. Reichmann: I object to that as calling for a conclusion.

2883 "The Court: Yes.

"Mr. Reichmann: He can state what was done and we will determine from that, or your Honor will.

"The Court: Yes, objection sustained."

Several million barrels of charging oil were put through thees stills during 1920 when we were operating without the pump. The yields at the beginning were considerably in excess of 25 per cent. Including

2884 the depreciation and interest charges and all operating charges, the cost of processing in these stills was at that time somewhere, as I remember between 50 and 60 cents a barrel. The total installation cost of the twenty-four units was a little over three mil-
2884 1431 lion dollars, and it took less than a year to pay for them. In the operation of these units we withdrew the residue and, as such, it was never returned to the system for further cracking, although the bottoms were redistilled and produced a distillate that we called cycle stock, wihch was returned to the pressure still.

2886 In March, 1921, the company received a communication from the Dow Pump Company in which they advised of a pump known as the surge pump capable of handling these high temperature liquids; immediately following that, we put them on a small experimental unit but soon after put one on battery 14 of our large vertical still commercial installation.

The Dow pump was patented. We obtained rights to operate under that patent. DX 760 is a patent to
2888 N. W. Thompson which is the patent covering this
2889 Dow pump, and we took a license under it when we started to use the Dow pump.

2890 As soon as we could determine fairly accurately the quantity of reflux that we would have, which was increased by this clean circulation and return of the reflux, we ordered pumps for all of our installations. It was somewhat over a year before all our installations were converted to using the pumps. At the same
2891 time we changed our method of refluxing and used bubble towers which were a more effective means of refluxing and took out all of the product other than gasoline and made a separation of commercial gasoline so that the reflux fluid quantity was greatly increased. In determining all of that we were delayed somewhat in arriving at conclusions as to just what capacity pumps we should have.

2891 1432 From that time on we did not install any other installations without the use of the pump for returning the backtrap.

2892 By 1932 we had installed, as I remember, 110 units in these various refineries. The total cost of those units was upwards of 20 million dollars. With clean

circulation in these units by the end of 1932 we had processed a little under 300 million barrels.

2893 The Texas Company directly licensed under these patents, including this Behimer application and the
2895 patent to Behimer, as of 1932, twenty units. The Standard Oil Company of Indiana, with what they put in and in their licenses to others, totalled thirty-seven. There were fifty-seven units outside of our own installations.

2896 We licensed direct the Empire or the Cities Service, the Ohio Oil Company, the White Eagle Oil Company, the Crown Central, the Elliott Jones; I think there was one called the Romsa built in Italy. We were collecting royalties on these licenses.

After the runs had been made on this coil and drum apparatus in the summer and fall of 1917, applications were prepared covering the whole pressure still operation processing contemplated, including the Burton stills and the coil and drum, clean circulation, and all features of our pressure still processing. Prior to that time when we set up this research laboratory at
2897 Port Arthur, we had placed a man by the name of Donaldson there who had been with us in the operations for the purpose of directly contacting the operations and the operators and making the initial drafts of patent applications.

Some time toward the end of 1917 I issued instructions that all of these matters should be covered
2897 1433 and the applications prepared, and that was done.

2898 I had a conference in Houston, one conference that I remember of, with Donaldson and Manley and, possibly, Dr. Gray, and some others, but with those I know, in considering these applications. That was either late in 1917 or early in 1918.

2899 The application covering clean circulation was ulti-
2900 mately filed in November, 1918. There were a number of conditions and circumstances which contributed to that delay. First, there was some confusion in determining in whose names these patent applications should be written or filed. I considered this development at that stage as practically one process, it was a pressure still process in which all of these features would be involved. Mr. Manley and Mr. Behimer had

contributed some to those ideas and development, and I had initiated some of them and been directing them
2901 in a general way. All employes were under contract to turn whatever they had over to The Texas Company for development, and at first I thought we should file in one name. I had no technical knowledge of what the patent requirement was. Promptly and properly, Behimer raised the question about his invention and I discussed those matters with Judge Beatty, our general counsel, and he said that we ought to file these patents in the names of all three. DX 757 is Donaldson's letter to me under date of January 22, 1918, in which he raised this question of inventorship. The
2902 first application came to me in my name*, but in my conference with Judge Beatty the decision was that it should be in the three names.** I did not think it would be treated as separate applications, I
2902 1434 thought it would be all one general application, I probably was not justified in that, it was not thought right.

All through 1917, our men were leaving to go into the service, something over 25 per cent of our men employes went into the service, and we were
2902 1435 short handed. Donaldson and Detweiler both went into the service, I think during the year 1917 and they were in part of '18. Mackenzie, our consulting chemist, who had made a great many or prac-
2903 tically all the patent searches and studies, was on some of the war committees and his time very much taken up, so there was a little delay there.

At that time we had contractual relations with Adams, and we did not want these applications and patents to be in conflict with Adams. So they were back for further study and Coit's opinion or determination whether our claims were in conflict with Adams. After that was cleared up finally, they were
2904 back to me again, and I raised some questions as to certain temperature ranges in the application. I had seen the effect of too narrow specifications or limitations and too broad ones. I was very anxious in all these studies that we cover carefully and thoroughly and get the fullest possible protection for what we had

*See DX 756, dated Feb. 2, 1918, and Donaldson Rec. p. 2779.

**Holmes so advised Mr. Manley on Jan. 30, 1918 (DX 761).

developed so we would have an operative and a protected process.

The last delay was in my office, when it came to me as I remember some time in October. I was a member of several committees and I was frequently in the West in board meetings of this sub-committee of the Foreign War Board, and in October I was in Chicago, or Kansas City, at a meeting of that Board, so there
2905 was two or three weeks delay in my office. At that time it had gotten to where I had no further suggestions to make and I indicated that at the time and then they were sent back to Washington for final filing and they were filed in November.

2908 DX 762 is a telegram I sent to Mr. Manley in Houston from New York on February 6, 1918, on
2908 1436 which I made a memorandum on the mail copy.

2911 DX 764 is a letter under date of March 19, 1918, from me to Mr. Lufkin after I had received the revised application from Mr. Manley (DX 763). It reads:

"In addition to the vertical stills construction of which I have written of even date, we have been quite successful in the development of a process and equipment for the manufacture of Gasoline from Gas Oil and Petroleum Residuums in a combination of high pressure heating coils, vaporizing chambers, etc.

"While the original plan was outlined by me to Dr. Gray and material ordered for the experiments accordingly, both Manley and Behimer have contributed materially to the final development of this process, and patent applications for this process and equipment, if made, will also be in the names of Holmes, Manley, and Behimer.

"This particular process I do not feel is as yet developed to the extent that I can at this time give definite figures as to costs and yields, but it is nevertheless of value.

"I think there is no question about the importance of applying for patents both on this and the vertical stills and process. The question as to whether we will have them issued must have consideration, but can be determined later."

I identify my signature on the letter.

1437 *Cross-Examination by Mr. Thomas.*

2926 I testified for the plaintiff in the suit of Texas *vs.* Anderson-Prichard and in part covered the same testimony as I did in my direct examination in this case.
2927 I testified in that suit about the Behimer so-called "clean circulation" patent which purports to be based on the plant 8 tube and drum experiments.
2928 In my direct examination I spoke of certain licensees under the Behimer patent. These licensees were under The Texas Company patents, that is, our general process and the patents that covered the process, and they included the Behimer patents embodying clean circulation.
2929 My recollection is that the first royalties paid to The Texas Company on an operation embodying the principle of clean circulation were paid on the units put in the Elliott Jones plant in San Antonio sometime in 1922 or 1923. Units of the Standard Oil of Indiana were installed around 1924 or 1925. Most of the units were installed at about the time of the Standard Oil units or later.

I never saw any unit operated by a licensee having a jet for returning reflux to the heating coil. We installed a pump having the Dow principles on our first
2930 commercial battery, identified as Battery 14, in the summer of 1921. The next installation was a Worthington type pump which was of the same Dow principle. I had no intention of representing that these
2931 pumps corresponded to the pump illustrated in the so-called Thompson patent DX 760, owned and controlled by the Dow Company except to state the fact that pumps of that principle were installed.
2932 1438 I do not know whether the first pump installed was a Worthington pump or not. It was a pump, however, using the Dow principle. It is my recollectinon that after the first installation on Battery 14 the Worthington people made our surge pumps.
2933 I saw the first commercial installation of the surge pump in 1921 and I remember that the vertical surge
2934 lines (pipes) were changed to horizontal lines. The blueprint DX 730 exemplifies the first surge pump installed in commercial Battery 14. The vertical surge

line on this print is approximately 36 feet in length.
2935 In the beginning the pumps were cooled by a trough which was open at the top and later may have been extended around the lines. I do not remember that the first installation had a connection for charging or priming the surge line with cold oil, but DX 730 shows that there was a connection of an inch and a half pipe for priming. I remember seeing this pump
2936 with a vertical line but I have no recollection of ever having seen any priming connection. I cannot recall all the details of the operation of the surge pumps.

In regard to the second installation of the surge
2937 pump I recall having seen a surge line with a double goose-neck. The lines were installed in this manner on account of expansion and contraction, and because we found that the straight lines chattered and were unsatisfactory because of the vibration. For this reason we installed the curved goose-neck arrange-
2938 ment in subsequent installations. I have a more or less indistinct recollection of seeing one of the goose-neck lines but cannot be positive. I was around the plants months at a time, although sometimes it might be a sixty-day interval.

At the time of the original installations of the
1439 surge pumps, we may have had some ordinary Worthington steam pumps but had no Worthington surge pumps. After Barry 14 we acquired
2939 Worthington surge pumps. The Worthington people supplied the pumps but The Texas Company made the installations, including the surge lines, that is, the thirty-six foot vertical surge lines and the double gooseneck lines that appear on DX 730 and DX 731

2940 Mr. Behimer made a disclosure of the idea of clean circulation to me early in August 1916. The question of whether Mr. Behimer had any means of returning the reflux was not raised. He did not tell me of this difficulty later. The information as to the difficulties of returning the reflux came to me later through reports and contacts with my assistants.

2941 I never saw the tube and drum experiment 8 operation in the summer of 1917, nor did I ever see any experiment by The Texas Company where an attempt was made to return reflux to the heating coil by means of a jet.

In 1925 or 1926 I saw the jet operating on one of

2942 the permanent operations, which I believe was Battery No. 1. It followed our installation of the surge pumps. There was a booster pump but I do not remember what the pressure was in the booster pump in the 1926 jet pump operation. I do not remember whether the 1926 set-up had an ordinary supply pump.

2943 From my own knowledge I cannot describe in de-
2944 tail the operation of the booster and jet pump in the
2945 1925 or 1926 operation and I could not swear that it operated. I had to depend on advice from others
1440 that it did, so that I am not in a position to testify on it, nor can I from my own knowledge testify as to the physical set-up of this apparatus.

I know that sometime after the summer of 1917 the experimental plant 8 tube and drum apparatus was dismantled and that it was proposed to build a semi-commercial or pilot plant to continue operations in connection with the clean circulation idea.

2946 I knew that the scheme had progressed to the point of making plans and attempts to get bids on all of the materials, but I have no recollection of ever finally getting all the bids and an estimate of the cost. I think they did not. I do not remember that there
2947 was a decision not to do it. I would have been responsible for any decision not to build this proposed pilot plant if any decision was made, but I do not
2948 know of any decision having been made. I do know that the plant was not built.

At the end of 1917, I called Mr. Behimer and some other assistants to New York. At this time we were under a good deal of pressure to obtain a commercial plant for cracking gasoline.

At this time we had no commercial process de-
2949 veloped, that is, no operation that we were satisfied with. The Hall plant might have been considered commercial, but it didn't satisfy us. Burton was available to us, but we didn't want that either.

During the war the Hall process was operated for
2950 a time for the manufacture of toluol. It may have been operated along in 1922 and 1923. This Hall operation was a minor one, and I do not know much about it except that some toluol was made. I
1441 knew that the Hall process for making gasoline was essentially a vapor phase process, and that

2951 the operation of the process was subsequently discontinued and the apparatus abandoned.

The purpose of the Hall installation originally was to determine whether we could make gasoline on a large scale from it. The Accounting Department made a study of the cost of the Hall process. On PX 637 there appears in my handwriting a notation, "68 cents gallon for gaso. R.C.H.". I think offhand that means the cost of the gasoline per gallon as I estimated it at the time.

2952 The Hall unit operated for toluol and for gasoline. I think that it is more likely that that 68 cents was the charge when operated for toluene. I do not think it could be 68 cents per gallon as the cost of gasoline.

2953 It is my impression that we made toluol during the time we were in the war. The report, PX 637, covers the period from November 22, 1916 to June 1, 1917 but before I could express on opinion as to whether this is the cost of gasoline I would have to analyze this report.

(Note: Witness then asked for time to give more study to this report, and the cross-examination on this point was continued on the next day. See below.)

2956 It is my impression that the Hall process was limited to a kerosene or re-distilled gas oil charging stock. I do not believe that the Hall process ever had any commercial successful runs, that is, profitable

2957 runs, except on toluol. I do know that I was advised that the Hall plant operated more satisfactorily on kerosene than on ordinary gas oil. I know that we abandoned the Hall process because we were not satisfied with it as a process for us to embody in a large operation; we had something better that was more profitable. The gas losses ran as high as 20 to

2958 1442 25 percent, and that was uneconomical in a gasoline making process.

I do not remember seeing the letter from Mr. Bailey to Mr. Behimer, DX 689. I remember that a figure of approximately $13,000.00 was used as what they thought this proposed unit would cost. I don't believe that there was ever a bid of $13,000.00 for

2959 the complete unit. I do not remember that I ever saw a letter, DX 690, and have no recollection of ever having received any bids on fittings. I don't know

whether they got the estimate of 13,000 through bids or whether it was an approximation.

2960 The purpose of the meeting with Mr. Behimer in New York in the fall or winter of 1917 was to decide how to set up the five stills that we employed on what
2961 we termed experiment No. 18. They were the stills which we intended to use as a unit to determine some of the unknown and undetermined factors to be arrived at in the larger installation which we contemplated. The stills were 5′ x 30′ and the permanent installation 5′ x 32′. As a result of these discussions in New York, our next experimental work involved the erection of three batteries known as experiment No. 18, batteries 1, 2 and 3. There were two
2962 batteries of two stills each, and one battery of one still, making five in all, and each still was five feet in diameter by thirty feet high. These stills operated both experimentally and on a commercial scale operation. They operated for several months from approximately March 1918 to October 1918. On Batteries 1 and 2 the reflux was always returned to the large stills where it commingled with the residual oils.

2963 About the same time we also operated Experiment 18, battery 3, and that merely involved one large still. For a number of months in the operation of that battery the reflux was always returned to the still
1443 until the preheater coil was procured. I know
2963 nothing from my own personal knowledge about any operation of experiment 18, battery 3, where the reflux was returned to the heating coil by a jet pump.

2964 Following the operation of battery 3, experiment 18, our next step in search for commercial operation involved the use of a heating coil with a battery of four of these vertical stills, which was known as experiment 18, battery 4. We operated this battery for some period. We put something over 100,000 barrels of oil through that battery. It was a commercial operation because of its large size and profitability. My information is that the reflux returned to the
2965 large stills and commingled with the residual oil.

Soon after completion of experiment 18, battery 4, we began the installation of twenty-four commercial units. Some of them were underway during the operation of experiment 18, battery 4. They began opera-
2966 tions as early as February 1920. Generally the de-

sign and construction was similar to experiment 18, battery 4. The reflux was returned directly to the stills and mixed with the residual oil. The permanent installation consisted of four stills, and in the beginning until we got the reflux pump that would serve the purpose the reflux was returned directly to the stills.

We put in twenty-four of these commercial stills beginning in February 1920. The final one was put in sometime in 1921. I know that all twenty-four were
2967 originally installed and operated with the reflux returned directly to the large vertical stills where it mixed with the residual oil.

In the middle of 1921 the operation of these commercial units was changed to return the reflux to
1444 the heating coil when we discovered the surge pump.

2968 In the Texas *vs.* Anderson-Prichard case I testified as follows:

"Q. I am not interested in what is claimed here at all. All I want to know is in your operation why was it that you returned your reflux or backtrap to the still, and not to the preheating coil for preheating reflux for the stream as shown in this patent?

"A. I will give the answer I gave before. We carried on an operation that way only because we had not found a means for forcing—this reflux through the preheater. As soon as we did have—the only reason for delaying was the inability to find that device and a means of forcing this reflux to this preheater in this system."

2970 According to that testimony, which is a correct statement, we had at that time no means or facilities to force the reflux back against the preheater pressure.

Mr. Coit had been counsel for The Texas Company and had assisted The Texas Company in its patent matters as early as 1915. I know that we had an op-
2971 tion from Adams in 1914, but I don't recall who represented us in this matter. In 1914, 1915, and 1916, I was quite familiar with the negotiations with Adams in these research problems and processing, but I was not so thoroughly familiar with the patents and applications. I attached considerable importance to the inventions purported to be covered by these Adams

applications. These inventions related to processes for cracking oil to produce gasoline.

2973 I have no distinct recollection as to when Coit's firm were employed and I don't even know the name of the firm. In the correspondence and conversation Coit seems to be the man of the firm in Washington who handled our patent matters at this time, 1445 when we were considering the applications for the Behimer and Holmes-Manley applications.

I received DX 608, a letter from Mr. Mackenzie ad-
2974 dressed to me, on May 31, 1918. This letter refers to the Adams applications. We acquired everything from Adams that he had. This letter refers to Adams' application serial No. 618,011.

I testified in the Texas *vs.* Warner-Quinlan suit in New Jersey which involved the validity and infringement of certain of the Adams patents that were owned by The Texas Company. I do not know whether the
2975 Adams application 618,011 was regarded by The
2977 Texas Company as one of the principal Adams applications. I don't remember the year but eventually we acquired rights under the Adams patents. My rec-
2978 ollection is that we paid Adams a quarter of what we received in royalties. I think ultimately it was more than a million dollars.

2980 I referred to the firm of Gifford and Bull in this way, that at one time or another they were our patent counsel. I don't know just when we had them but they were employed as consulting counsel for The Texas Company for a long period of years. I believe that
2982 this firm represented The Texas Company in the Warner-Quinlan suit. They were consulted in connection with the Jersey case against The Texas Company under the Rogers-Adams situation, which I think was in 1922 or 1923. I cannot say when their employment began and when it ended.

2983 I testified on page 223 in the Texas *vs.* Anderson-Prichard case as follows:

"Q. And as I understand it, you paid five million dollars for the equipment that incorporated this installation without the return of the reflux to the entrance of the preheating coil?

2984 1446 "A. I think I said those first twenty-four units cost a little over three million dollars.

"Q. And when you changed the operation to put in a surge pump, all you did was to put in a pump in

the reflux or backtrap line and pump it to the inlet of the preheater coil rather than to the first of the stills. Is that correct?

"A. That was the change in principle of the operation and we changed the refluxing—."

1447 *Redirect Examination by Mr. Thiess.*

2985 The larger coil and drum pilot plant that was contemplated after we made the runs in the fall of 1917 was not built. My information was that we could not and did not get all the material.

2987 I have no recollection of their ever having gotten quotations and promises of delivery of all of the material, and any estimate that was made in DX 690 I am quite sure was made without all of the final figures. It was an approximation.

The purpose of operating these batteries 1 and 2 of experiment 18 for the months stated was to know more about the effect of the application of heat, the furnace arrangement, etc., before we went on with the larger installations which we contemplated. We

2988 were confident that we could make gasoline even though we were delayed indefinitely in getting coils and fittings and a facility for returning the reflux. We were confident that we could go on and make gasoline with the shell type stills rather than to take up with the Burton. As executive head, I convinced

2989 our board that we could put in vertical stills and get better results at less cost than we could with Burton, and that we had patent protection to do it with, and that the rest of this, I looked upon the whole thing as a process, as we could get coils and fittings and pumps that were suitable and effective we could put them on.

2990 Mr. Thiess: "Now I would like to read into the record, if your Honor please, the matter from the Anderson-Prichard record on page 232 following immediately what they read into the record:

2990 1448 "'Q. You mean you were not able to find a pump to do it?

"'A. Not in a large way. The back pressure was high, and we were unable to find, had not found anything up until 1921 that would do that in a satisfactory way.

"'Q. And in 1921 you found a pump that would be satisfactory for that purpose. Is that correct?

"'A. Yes.

2991 "'Q. Then did you change these stills so you returned the reflux to the preheating coil?

"'A. We did, just as fast as we could.

"'Q. And the pump that you found was a surge pump, was it not?

"'A. Yes.'"

1449 *Recross Examination by Mr. Thomas.*

2993 I have examined the accounting report PX 637 that I took with me last night. The notation that appears in my handwriting on the report: "68 cents gal. for gaso." is apparently the result of a rough calculation that I made myself on receipt of this state-
2994 ment. Deducting from the entire cost of the charge plus all of the expenses the value as stated of the by-products and dividing the remainder by the gasoline yield results in approximately the 68 cent value, but in fairness to the statement, so that you get the real understanding, it was a research effort searching for information rather than for profit making, and no allowance was made for the gas loss, which had a fuel value. In a commercial operation, of course, you would use that as fuel, so that it would make some reduction in the cost, but it still was a high cost.

2995 The value of the gas would not be negligible because it was about 20 per cent of the entire charge. We could have piped the gas over to the boilers, but we had no market at that particular time for the gas. It is fair to state that wasting the gas as they did, the cost was 68 cents a gallon.

2996 I telephoned New York about this report. Apparently it is a statement made up by the chief clerk of the laboratory division where this was made, and it was in the course of the routine that it came to me.

1450 HARRIS A. SMITH, New York, N. Y.:

Direct Examination by Mr. Thiess.

2667 I am senior engineer with The Texas Company. I have been employed by The Texas Company at this period since December 1, 1927.

2668 I first started with The Texas Company at the Port Arthur, Texas, refinery about the first part of February, 1916. I was there continually until the first of June, 1918.

I left on June 1st, 1918, to enter the air service and I came back on April 1, 1919, and stayed until November 1, 1919 and that terminated that first period of service.

In the beginning I was employed by The Texas Company as a sample boy and later was in the laboratory as a tester for a few months, after which, about the latter part of May or first of June, 1916, I asked for and received a transfer to the engineering department in the drafting room.

2669 I had a short apprenticeship about thirty or forty-five days in order to get acquainted with the refinery, and then after that I went into the drafting room proper and began my work there.

The method of procedure followed in the drafting department with respect to the numbering of tracings and blueprints was this:

On the tracings, we simply numbered the tracings serially. As a tracing was completed it was given a number, and the next number in rotation was

2670 1451 assigned, regardless of size, and as I say the number was assigned on the day the tracing was completed and then an entry was made into a record book of the number of that particular tracing, its title, its size, its scale and the date of completion.

We had a small book or form containing substantially the same information which we followed for a blueprint record. In this case numbers were stamped into the blueprint record and as a blueprint was struck off a tracing a stamping machine was used to number each blueprint serially and in accordance with the numbers, the title of the drawing, the scale and the

date of the issuance of the blueprint and the name of the party to whom it was to be charged was entered on a number corresponding with the number stamped on the blueprint.

I remember the first assignment I had to make drawings.

2671 My first assignment to make a drawing of an apparatus already constructed was of a coil still constructed in a corrugated iron shed to the rear of the office building, and I went out into the field to take measurements so we could make a tracing or permanent record of the equipment as it then existed. I would say it was around the first week or two weeks of August, 1916.

DX 666 is a blueprint of drawing 1562 which I made of the apparatus in existence at that time. That apparatus was designated a coil still. The original drawing was made September 18, 1916 and I put that date on that drawing.

2672 1452 DX 663 is a blueprint of a tracing of a Redwood experimental still, which was constructed and in existence alongside the coil still in the same shed at that time. The original drawing or tracing is numbered 1568. I made the original drawing on
2673 September 19, 1916. That date on the drawing was put there by me. I measured the apparatus and then made the drawings.

At the time of this first assignment I went to the shed where I found Mr. Otto Behimer and introduced myself, and we discussed what I was to do. This was the first week or two weeks in August, or thereabouts.

DX 665 is a photostat of a sketch, which was made by Clarke & Abbey of the coil still as it then existed. It was turned over to me by Clarke & Abbey at the time I went out to the building. DX 665 has inscribed on it the date of August 17, 1916, which was the day they evidently completed the work and turned it over to me. That was my first visit to the apparatus.
2674 Clarke put the date on this drawing. I was present
2675 when he did it.

After I had introduced myself to Mr. Behimer, I had a conversation with him respecting these drawings I was to make. I told him that I was there for the purpose of taking measurements and making

drawings of the equipment in existence as permanent records for the engineering department, and he very promptly told me that he was not concerned with the old equipment.

2676 1453 Mr. Behimer told me that he was not concerned with anything that was there then but
2677 that what he wanted was a draftsman to draw up equipment which he had in mind and that he wanted built. He said he would like a coil substantially as the one that existed, with the exception that he would like tubes of uniform length, that he would like a drum in connection with the coil situated outside the
2678 furnace, into which the coils were to discharge the heated oil; the drum should have a drawoff for tar or residue and an overhead vapor line for conducting vapors to an air condenser or header, as we called it then, to be situated above that, which itself was to have a condensate or backtrap drawoff which was to be carried back and mixed with the fresh charge and pumped into the coil; the air condenser or header should have a vapor drawoff which was connected to a water coil condenser and from which a product was taken to an accumulator drum. Mr. Behimer said that he was up against a problem and that he had no means of returning or pumping back the backtrap; that he was limited by the pumps which he had in the plant or which were in existence, none of them being suited
2679 to that particular job, and that he didn't have anything to do that piece of the work with. There was not much further to it except the fact that I took up the problem, as my own, of thinking about a means or devising a means for handling this backtrap into
2680 the fresh charge and the mixture back into the
1454 coil. I got busy and began to look around for a suitable means for doing this work, and as a result of that I made the suggestion that we might use a jet pump of the siphon type and began to search through catalogs to see if we could purchase one. We did not find a suitable one that we thought would do the job and accordingly later constructed one at the plant.

2681 I told Mr. Behimer about this jet pump. We discussed it on several occasions. I told him I thought that we could possibly buy one from Schutte-Koerting, who made jets at that time, but on further search

it seemed that the particular type that we were looking at was of a steam siphon jet which probably would not be operative on two liquids, and we abandoned that idea and later designed and constructed one of our own origin.

I prepared a drawing at Mr. Behimer's suggestion. It followed right along with the other two drawings D. X. 663 and D. X. 666; it came right along just after them. I began the work constructing the apparatus on paper in the drafting room first, and in accordance with our usual practice laid the work out on the drawing board with pencil on a paper tracing form that we had at the time, and as the design work progressed I would ink in parts of it, that is trace it in with a tracing pen, and on occasion Mr. Behimer would come into the drafting room and see the work as it was going along.

2683 About the time the drawing was finished he came in and we made some changes in the location of
1455 some of the parts of the equipment. As I recall, having looked again at one of the prints recently, the air condenser was moved nearer to the coil heater and the vapor line from it was taken off to the other coil. In other words, the positions of the drum and
2684 the air condenser were changed relative to the coil. I had shown on the tracing a Schutte-Koerting jet which was improperly placed in the line. That was scratched out and the word "void" written through it, and when we changed the position of the backtrap line where it entered the coil entrance to the furnace proper we showed a simple siphon jet type of pump there. Following out these suggestions of Mr. Behimer the changes were indicated on the drawing. That was done in pencil on the tracing myself at the time
2685 that I talked to Mr. Behimer. We destroyed this tracing that I made. It was on paper and most of it had been inked in or traced in and couldn't be erased, and to shift the positions of those pieces of the equipment required a major operation on that drawing. The paper this was made on was a glossy, regular glossy tracing paper, fairly transparent.

I assigned a number to this drawing that day. The blueprint under glass is a print of the tracing that
2686 I made and was made for Mr. Behimer before the tracing was destroyed to use to figure on, to refer to

in his consideration of the equipment to be built. There were no other blueprints made of that tracing. Numeral 1 on this line on the photostate DX 667 indicates the charge line entering the jet pump A. The line or loop 2 is the charge line which goes on into the upper portion of the coil still. C indicates the air condenser or header, as we called it then, and the numeral 5 is the vapor line leading from the upper portion of the drum into the bottom portion of the air condenser. D indicates the changed position of the air condenser. B apparently indicates the new location of the jet pump in the charge line where the backtrap was merged with the charge oil and pumped back into the—pumped into the coil. "A" shows the jet pump as it was originally placed and scratched out. "B" shows it in its new place—in its new location.

The date on the original tracing was November 6, 1916, and was put on there on that date by me. I entered that in the tracing records. The number of this tracing was 1648.

The tracing record DX 752 calls for a Burton still layout. The number 1648 on that tracing record calls for a Burton still because when I marked this tracing to be destroyed, I also obliterated the number which had been assigned to it and I reassigned the number to a Burton still layout which was later made by me.

DX 753 is a blue print of the tracing numbered 1648 and entitled "Burton Stills Layout." The date of this tracing is January 29, 1917. I put that date on there on the day the tracing was finished.

DX 754 is a blueprint of a tracing which I recently made on April 22, 1936, reproducing as nearly exactly as possible the original blueprint DX 667. This was done merely so we can see it in better shape.

Describing the apparatus shown on DX 754, beginning with the charge line, the charge line is connected to a jet. The charge line 1 enters a jet pump 2 and from there on is carried through a line 3 to the entrance 4 of the coil heater 5. Now, the oil from the coil moves through 6 into the drum 7, which was provided with a tar drawoff 8 and an overhead vapor line 9, which was connected into an air condenser 10, which was provided with an overhead vapor line 11 and a backtrap drawoff 12.

The drawing at the left-hand side of the drawing is a part elevation and part transverse section of the front end of the furnace. That shows the number of tubes in the furnace. Fourteen tubes are shown.

2702 After Mr. Behimer had directed that these changes which I have pointed out were to be made on the draw-
2703 ing, I marked the drawing to be traced over, not to be destroyed but to be traced over, but I don't recall having destroyed the original drawing after that.

DX 669 is a new tracing made immediately by B. R. Schneider following this one that I had made. I had
2704 nothing to do with the preparation of this drawing from the start. I made some changes in the details in the lower left-hand corner of the tracing having to do with the rivet hole spacing where this manhole was to be attached to the drum. I also made a change in the date opposite the printed word "Date" on the tracing, and I added the letter Y to the number.

DX 733 is a sheet from the tracing record on which this drawing, DX 669, number and title and other data
2705 were recorded. The tracing record shows the number 1703, the date of 12/4/16, indicated by a check mark under a similar date above, and reference data such as title "High Pressure Still Estimate,"
1458 "2,000"; under "Scale," "None"; under "Size," which indicates the size of the tracing, "22 x 34," meaning 22 x 34 inches; and under the title "Revised," "1/29/17."

2706 At the time this drawing 1703-Y was completed, prints were made in the customary manner and sent to the boiler shop for the fabrication of the drum; and when it reached the shop the rivet spacing as given on the original drawing was found not to be conventional in accordance with best shop practice, and we received some sort of word, criticizing the rivet spacing as contained on the drawing. So we then checked a fabricator's handbook which would give conventional rivet spacing, and made notes on here, changing this accordingly. I made those notes.
2707 I then considered that I had made a sufficient change to the drawing that I changed the date on it. I changed it to the date on which these notes were made, which was the 7th of December, from the 4th of December.

My superior criticized me for this change quite severely, and I was quite embarrassed by the thing,

and got the tracing back again and changed the date to the 4th. In the meantime, before I had changed it back to the 4th, we had made additional blueprints taking in these changes here and had sent them to the shop. It was possibly a little while before he discovered that, and when he finally did, I really got
2708 it in the neck good and proper. He criticized me again much more severely than before, and said I had just added bad to worse. The change was then made to the 7th of December and the date on this has remained 12-7-16.

2708 1459 The month and the year given in that date on DX 669 were not changed in any way whatsoever. The only change that I made was from a
2709 4 to a 7 and then back to a 4 and back to a 7. The 7 in the date 12-7-16 appearing on DX 668 is the first
2712 7 which I made when I made the first change. The 7 appearing in the date on DX 669 was my second or last 7.

2709 When I first started in the drafting room we had a relatively small number of tracings of various sizes which we numbered in rotation serially, regardless of the size. As the number of the tracings increased, there was considerable confusion in segregating the different sizes of the tracings or locating one when you needed it in a hurry. So we devised the system of adding a letter to the numbers on the tracing to designate the different size of drawings.
2710 That system was put into effect some little time after DX 669 was made, i. e., the early part of 1917, January or February. I added the letters to the numbers on the existing tracings myself.

2711 I saw an apparatus constructed which corresponded to this DX 669 in the early summer or summer of '17. On trips passing the building where this equipment was located I would stop by and have
2712 a look at it. I didn't minutely examine that apparatus that I saw there, but I would say it was generally the same as the apparatus shown on this drawing DX 669.

2714 DX 685 is a photostat of a sketch which Mr. Behimer gave to me and which I followed in making a working drawing of further apparatus to be constructed in connection with the Behimer idea. Mr. Behimer, when he gave me this sketch, in the first

2715 place said that he wanted to have a much
2715 1460 longer coil of smaller diameter tubing; that he wanted to increase the size of the drum and the air condenser, and in general he instructed me to follow the pencil notes which he had written on the side of the sketch and which appear on the photostat. DX 686 is the drawing which I made in compliance with those instructions. It was completed on September 24, 1917. All the drafting work on that drawing, strictly speaking, is mine, but there are some pencil notes on there that are not mine. I do not know anything about those pencil notes. These
2716 dates are all my handwriting. They were put on, I would say, the same day or just almost simultaneously with the date which is the completion date of the drawing, and that date is 9-24-17.

DX 695 is another drawing I made of this same apparatus. It is a diagrammatic drawing of the
2717 apparatus, which I made at the time a patent application was prepared. William T. Donaldson, our patent attorney, instructed me to make that drawing. That drawing was completed on January 4, 1918. I put that date on that day.

There are pencil notations on DX 669 that I made. The words "Show burner" appearing in the section through the center line of stills at the burner opening as provided on the drawing, and the word "target" have been placed on this tracing in pencil. There is also an elevation view of the checker brick work in
2718 the arch showing the method of staggering the holes. These pencil notations were made for the purpose of clarifying those features to Mr. Donaldson at the time of discussing DX 669 with him and following which DX 695 was made.

1461 *Cross-Examination by Mr. Blenko.*

2719 I had some formal instruction as a draftsman in 1916 prior to entering the Engineering Department of The Texas Company. My training period with the company was for the purpose of becoming acquainted with the physical lay-out of the plant and equipment.

My apprenticeship began about June 1, 1916, when I entered the engineering department, and continued

for about forty-five or sixty days. I went in the drafting room about July 15th and began my training in the routine of the drafting room. I possibly knew
2720 at this time that it was the common accepted practice to number drawings and tracings as of the date of their completion.

The tracing records and the blueprint records were permanent records of The Texas Company. They are
2721 the only permanent records insofar as they reveal the fact of disclosure of structures to others by way of drawings, with the exception that some photographs were made of certain equipment as the construction work progressed.

2722 I did not have the drawing, DX 665, when I first went out in the field, but got it when I went to the field. I was sent into the plant of the experimental
2723 department to make a permanent record of the old coil experiment (Experiment 8, without the drum) and Mr. Clarke introduced me to Mr. Behimer. Mr.
2724 Clarke handed me DX 665 at that time. DX 665 is dated August 17, 1916, and that was the date I first met Mr. Behimer.

I was told to go out and measure the apparatus as exemplified by DX 666 and to make a drawing of it, as a part of the permanent records of The Texas Company. I understood that this was experi-
1462 mental work and that the company was trying to work out a cracking process.

At this time, I did not recognize that there might be an invention involved and that the dates were
2725 important. I did recognize this in the latter part of 1916 when I became acquainted with Mr. Donaldson and learned that he was following the experimental work for that purpose.

Mr. Donaldson was transferred from Houston to Port Arthur in the fall or early winter of 1916, and I fix the date of my knowledge of the importance of this experimental work approximately as of the time Mr. Donaldson came to Port Arthur.

2726 The dotted line marked A in DX 663 represents the horizontal lines produced by the intersection of the arch of the furnace roof, inside of the furnace, marked C, with the horizontal portion of the roof, marked B. The line B in the right hand view corresponds to line A marked in the middle view. The

arch indicated by the lines B and C on the righthand view of this exhibit represents the top of the chamber
2727 in which the cylinder or drum is mounted. There is a large fire space around the top of the drum at the rear. Line A extends for at least two-thirds of the length of the drum and indicates that a very large portion of the drum was exposed to the combustion gas above the center line of the drum. Thus if the liquid level were at the center of the drum, a large portion of the drum surrounding the vapor space was exposed to the combustion gases.

I did not make any of the pencil sketches shown on DX 686. The only part I made is in ink. I do not
2728 know when the pencil sketches were put on. I
1463 had DX 685 before me when I undertook to make the drawing DX 686. None of the nota-
2729 tions on DX 685 are in my handwriting.

I recently testified on behalf of the Texas Company in the case of Texas *vs.* Anderson-Prichard on Behimer patent. On page 789 of that record, referring to the drawing of November 6, 1916 (DX 667 in this case), I testified as follows:

"Q. Before going into the changes, Mr. Smith, will you tell me why it was that you didn't make this drawing for Mr. Behimer sooner than November 6, 1916, after he had explained what he wanted to you back, I believe you said, in August, 1916?

"A. Yes. This was considered more in the nature of experimental work, and we had other rush construction jobs which were to be undertaken and which took precedence over this type of drafting work in the engineering department, and which we had to complete. We may have been instructed to
2730 have taken it up even after this job was started and drop it and then go ahead again with the other work and then maybe go back on this for a short time and be pulled off again and still go back again and so we hit it a lick now and then as we could when it was convenient."

It was just a matter of a few days after my discussion with Mr. Behimer that I suggested the jet to him. In the meantime, I had looked up the jet in the Schutte and Koerting Company catalogs. After a few weeks I concluded that the steam jet shown in

the Schutte and Koerting catalog was inoperative for our purpose.

2731 In the first place, the idea of the jet came to me from a study of the small steam syphon jet which we used for pulling water out of concrete foundations. I then discussed the jet idea with Mr. Behimer. Following that I studied Schutte and Koerting's catalog and I discussed with John S. Gallagher, who was one of our senior engineers at that time, the possibility of using such a type of jet, and he sug-
1464 gested that a steam jet probably would be inoperative if used for two liquids.

2732 Ordinarily in the use of a steam jet it is so designed that in the main chamber there is created a partial vacuum by condensation of the steam which is used as the impelling medium and through the use of the vacuum it increases the pumping capacity of the jet. In a jet used for two liquids it is necessary to depend entirely on the kinetic energy of the impelling liquid without aid of the vacuum to move the impelled liquid, that is, the impelling liquid furnished all of the force, and it must be a substantial force sufficient to create suction.

We then began to discuss the matter of a home-made jet suited to this particular purpose.

Referring to DX 686 and DX 685, Mr. Behimer wanted the coil to be longer, the pipe making up the coil to be smaller in diameter, the drum to be larger, and the air condenser to be larger.

2733 I made the air condenser larger than in the old apparatus, that is, made it greater in length, although the diameter was not much different. It was made of 10-inch pipe. Mr. Behimer explained that he wanted the coil longer and of smaller diameter in order to have greater velocity in the heating tubes. He did not then say that he wished the greater velocity in order to avoid stratification of the oil in the coil.

2735 In my direct testimony, I stated that I saw the Behimer apparatus known as Experiment 8 in the early summer or at the latest the summer of 1917. In the Texas *vs.* Anderson-Prichard case, I testified on page 795 as follows:

1465 "Q. And when did you see that apparatus?

"A. I will say during the summer or fall of '17."

2736 Numbers were assigned to blueprints issued by the engineering department of The Texas Company, and these numbers were recorded in a book similar to that of our tracing record. I believe it was a loose-leaf book. Whatever blueprint happened to be issued it bore the latest number and opposite that number the number of the tracing was inserted, and the same number was stamped on the blueprint with a stamp-
2737 ing machine. This practice still persists, and according to my recollection this was the practice when I entered the blueprint department. There were times, of course, when the numbers were inserted on the prints in pencil or in ink.

The number invariably was inserted in the space that appears in the title box under the legend "Print No." if the instructions were followed.

The blueprint number on DX 667 looks like 9048, although I cannot make it out very well. Referring to DX 667 there would be two records, one of them the tracing record bearing the tracing number 1648,
2738 then in another book in its regular sequence an entry of the print corresponding to the print number appearing on the blueprint. In the same blueprint record I would find a record of any other blueprints made off the tracing. These blueprint records were a part of the permanent record of the engineering department. It is possible that if a number were changed on a tracing the consequence would be that the blueprint record would not reveal the subject matter of the drawing whose print was actually issued.

Mr. Schneider made drawing 1703 Y (DX
2739 1466 669) from the earlier drawing, DX 667. DX 669 was made on December 4, 1916, and revised January 29, 1917. It was made, then, prior to the drawing of the Burton still, DX 752, and yet DX 669 was given a number different from DX 667.

The witness then testified:

"Q. Can you point to any other case in these tracing records where a drawing was destroyed after it had reached such finality as to have assigned to it a tracing number and then another drawing substituted?

"A. Well, I have never searched very carefully but I rather think not.

"Q. This is the only case, then, in all of your experience where you know such a thing was done?

"A. That is right."

I made some revisions on DX 669. The tracing
2740 record contains a column to show the making of such revisions, and the drawing itself has a space in the title box to show the dates of such revisions, but I did not enter anything either on the tracing record or on the drawing when I made those revisions.

I changed the date in the title box of DX 669 three times. The first change was 4 to 7, the second was 7 to 4, and the third was 4 to 7. I did all of that without making any record of it despite the fact that I had been criticised for changing it in the first instance and criticised again for changing it in the second instance.

2741 My superior was Max B. Higgins. He is still living and is employed by The Texas Company.

The longhand notation in the title box of DX 667 reading "(To be traced over)" is in my handwriting.

I did not order the original tracing to be
1467 destroyed nor did I give any instructions other
2742 than that it was to be traced over. It was then turned over to Mr. B. R. Schneider under Mr. Higgins' instructions, but what happened to it after that I do not know. I do not know whether it was ever destroyed in fact, and so far as I am concerned it may still be in existence.

2743 Referring to DX 752 and particularly to the entry after "Drawing 1648," there is no indication that there existed in the month of November, 1916, any drawing corresponding to DX 667, nor is this indicated on any other record of The Texas Company. I therefore erased the only permanent record of this drawing.

The witness testified as follows:

"Q. Then you did destroy the only permanent record that The Texas Company had of this drawing supposedly existing in November of 1916?

A. Apparently so.

Q. And thereby destroyed the whole purpose of the record, didn't you?

A. I can't answer that.

2744 Q. You did this in January of 1917 just a few

weeks after you had been repeatedly criticised by your superior for altering the drawing No. 1703 Y?

A. No, the chances are I did it just about the time that tracing was noted to be traced over, which was the date of November 6, I recall.

Q. How could you have done that when the present drawing 1648 is dated January 29, 1917?

A. Because when the tracing of the coil still, which had the notation on it to be traced over,
1468 was so noted and dated November 6, on that same day I believe that I erased the words 'Coil Still' from the tracing record."

The handwriting on "Drawing No. 1649" is not in my handwriting. What I erased was the entire entry that appears on the line after Drawing "1648." The line was left vacant until January of 1917.

The witness testified as follows:

"Q. Did you in the Texas *vs.* Anderson-Prichard record testify as follows on page 792 in respect to that same drawing No. 1703 Y:

'Q. I show you a drawing, Plaintiff's Exhibit 4, and ask you if you recognize that drawing?

'A. Yes. It is a photostat reduced in size of the final drawing.

'Q. And what is the date of this drawing 1703, which is Plaintiff's Exhibit 4?

'A. That shows 12-7-16, December 7, 1916. Incidentally there is a bad blur right over here, a portion of this date, on this photostat.'

2746 "And did you not testify as follows on page 793:

'Q. Do you recognize any of your handiwork on this drawing here, Plaintiff's Exhibit 4?

'A. Yes.

'Q. What for instance?

'A. The "Y" was put on there by me, for one thing.

'Q. Is there anything else you can recall that you remember?

'A. Yes, there are some notes in the lower left-hand corner of the tracing with respect to the spacing of holes in the manway covers, number of holes, sizes.'

"A. Yes, I did."

1469 I gave no testimony in that case as to the drawing bearing an original date of December 4th, or of my having changed it.

2747 I have looked through the tracing record covering the month of January, 1917, which covers the period in which the drawing 1648 was supposedly made. I do not find any reference to the drawing now numbered 1648.

1470 *Redirect Examination by Mr. Theiss.*

2747 I find a record of this Burton drawing on the tracing record DX 752. There is no date shown.

2748 The blueprint number on this original blueprint of which a photostat is DX 669 is 9063. That is written on in pencil. It must have been that the stamping machine was bought a little bit later, because evidently we were not stamping them in at that time.

2749 DX 668 has a blueprint number on it also written in in pencil.

No entries were made on the tracing record in connection with the changes which I made in DX 669, because I changed the date to suit the date of that change.

1471 *Recross Examination by Mr. Blenko.*

2750 In DX 662 and DX 663, dated January 4, 1915 and September 19, 1916, respectively, the block under the words "Print No." bears a number stamped in with a machine.

The tracing records were in general in chronological order. It was common practice not to insert any date where the date was the same as the date of the preceding entry, that is, if the date was the same as

2751 the preceding date it was either checked or dittoed. Referring to DX 752, drawings 1649 and 1650, there is no indication of their date on this record.

I do not know when the drawing of the Burton still, No. 1648, was made. I didn't make the drawing.

2752 I did make the tracing. Mr. Higgins told me to make the tracing.

1472 *Redirect Examination by Mr. Thiess.*

2752 I can't tell you when the prints which are DX 663 and DX 662 were made, but the original tracing of
2753 DX 663 was made on September 19, 1916. I made the drawing of DX 663. DX 662 was made before I went with the company.

On this matter of putting a blueprint number on the print, the date of the tracing would not indicate at all when that number was put on. The blueprint number would be put on on the day the blueprint was made. It might have been made ten years after the drawing was made. I did not mean to represent
2754 that the blueprints were in existence in 1916. I don't know when the blueprints were made. I was talking about the drawings.

1473 WILLIAM T. DONALDSON, Mount Vernon, N. Y.:

Direct Examination by Mr. Thiess.

2756 I worked for The Texas Company as early as 1908, at Port Arthur, Texas. I was re-employed on
2757 July 15, 1916 to keep track of the experimental and research work that was being conducted for the purpose of affording patent protection to the work. I had just been admitted to the bar in 1916.

2758 I know Mr. Otto Behimer. I met him in 1916. At the end of July, 1916, I went down to Port Arthur to investigate some electrical inventions, and while I was there on this trip I met Mr. Behimer. We had a little general discussion about the work that he was doing and the work that he proposed to do, and
2759 he said that he had in mind a process that was going to be the way to crack oil to make gasoline, and he said that what he proposed to do was to charge the oil through a heating coil and raise the oil to a cracking temperature in that coil, and pass the oil into a cracking drum which would be maintained under super-atmospheric pressure and at a cracking temperature by the heat of the oil entering from the coil.

He said he wanted to put the cracking heat into the oil in the coil and maintain the cracking temperature in the drum. He said that he wanted to draw off the residue, take it out of the system and pass the vapors overhead from the drum up to a dephlegmator or air condenser, I think he called it, and in this dephlegmator or air condenser the heavier constituents of the vapors would be condensed and the lighter uncondensed vapors, including the gasoline, the desired gasoline product, would be passed over to a con-
2759 1474 denser coil and collected in, a receiving drum, and the heavier condensed constituents would drop down from the dephlegmator and be returned to the heating coil. He said that he wanted to pump
2760 the oil through at a rapid rate through that coil and that he considered it to be desirable to take the back-trap or the reflux condensate from the dephlegmator and pump it back so it would go through the heating coil with the charge and be subjected to a cracking temperature in the coil.

That conversation took place on my first trip to Port Arthur which was on July 29, 1916. At that time he said that he contemplated pumping back this reflux condensate at a high rate through the heating coil and that he was looking around for a good type of pump to do that with, that the ordinary pumps wouldn't stand up under the temperature and pressure; that is, the packing would rapidly deteriorate and the pump couldn't be operated for any great length of time.

2761 Some time after I had returned again to Port Arthur, Behimer said, "Well, we have worked out that problem of the pump." He said, "We are going to use a jet pump." He explained to me just briefly how a jet pump would operate, the charge going through an orifice would suck in or tend to suck in the condensate in the dephlegmator leg so that it would be forced in with the charging oil through the coil.

2764 I was very closely in touch with all of Behimer's work. My office was right next to his and I would see him every day and we were in daily conversation about everything that he was doing. I was perma-

nently transferred to Port Arthur on October
2764 1475 22, 1916.

2766 I saw apparatus in which Behimer incorporated the jet pump and the other apparatus. I saw in operation this process that Behimer had described to me. I saw this apparatus in the summer of 1917.

2767 The apparatus was put up right back of the laboratory and right where I could see it every day, and it was operated there, and I was right there during the time when the apparatus was operated.

The apparatus that I saw consisted of a furnace in which a heating coil was mounted. This coil consisted of lengths of pipe, I think about 20-foot lengths, about 14 of these tubes, and they were connected for serial flow through the tubes, and the outlet from the coil terminated in a drum, a cracking still, and there was a vapor line from the top of the still which had an inverted U-bend in it, and extending to an air condenser, and an overhead vapor line went from the air condenser to a coil in a water box, and there was a backtrap or dephlegmator leg leading from the air condenser downwardly and through a U-bend coming back up into the charging line at a connection which was a jet pump. The bottom of the drum had
2768 a line for drawing off residue.

At a subsequent time I prepared a patent application upon this coil and drum process. The first draft of the application was made in December, 1917. I enlisted in the signal corps on the 13th of December, and it was right after this that I became active in preparing this application. I was called over
2769 1476 to Houston and had a conference there with Mr. Manley and Mr. Holmes, and Mr. Holmes authorized the filing of an application, so I prepared an application in December right around Christmas time when I was working there.

DX 755 is a blueprint that I used when I prepared the first draft of the application. I identify it because of various reference numerals here which are in my handwriting and which I put on the drawing when I wrote up the case.

2771 DX 694 is one of the drafts of the specification that I prepared on this invention of Behimer's. This is

my working copy and was used in revising the specification.

2772 On Page one, the opening paragraph has been written in in pencil by me. That is the paragraph referring to the inventors. The three names here are R. C. Holmes, F. T. Manley and Otto Behimer. Down toward the end of the page, I have scratched out a certain line and written in another line in pencil and then, as a matter of fact, I changed that again and had the final wording on a little slip of paper which was pinned on here but which has gotten lost in the shuffle.

2773 On page 2 there are some more changes that I indicated in pencil and at the bottom of Page 1, I have scratched out the last three lines. Some of the handwriting is in Mr. Behimer's writing.

Attached to the bottom of Page 2 is a typewritten sheet containing an insertion to be made at the bottom of the page.

On Page 3 I have scratched out a portion of the first line and inserted words here and there.

2774-2776 Pages 4, 5, 6, 7, and 8 have also been corrected and changed.

2777 I have changed "I" to "we" for the following
2777 1477 reasons: The first draft of the specifications which I prepared was drawn up in the names of R. C. Holmes and Otto Behimer. Then I received instructions to write the case up in the name of R. C. Holmes and then, later the instructions were changed again and I was instructed to prepare it in the names of Holmes, Manley and Behimer. These instructions were not made in writing; they were given to me verbally, first by Mr. Holmes when I was in Houston when he said to prepare the case in the names of Holmes and Behimer, and then—And, of course, that is what I did in the first draft.

The application was written early in January, 1918. I can fix that date because there was a patent drawing made which the record shows was made on January 4, 1918, and there is other correspondence in the file also that shows it.

7279 DX 756 is a letter that I wrote to Mr. R. C. Holmes, dated February 2, 1918, containing the draft of the application in Mr. Holmes' name and including also

2780 a print of drawing, U-2310. This draft, as I said, is in the name of Ralph C. Holmes and in looking through the draft I find repeatedly the pronoun "Our," which indicates that I had neglected to change the plural pronoun over to the singular. It is that first specification which I prepared in the name of Behimer and Holmes that I am not able to locate. This specification which I have just identified,
2782 attached to the letter of February 2, 1918, is my second draft. The specification which is at-
2782 1478 tached to this letter of February 2, 1918, is a carbon copy, and this draft, DX 694, was the original copy except that I believe that the first sheet was typed over separately leaving a blank space up at the top for the names of the inventors, and I inserted these changed names up in this blank space
2783 in DX 694 and now has had added pencil revisions and changes. These changes on DX 694 were made in February, 1918. I give that date because the records show that the revised application was sent to Mr. Manley on February 19, 1918.

The first instructions were to prepare the case in the joint names of Holmes and Behimer; and then later Mr. Manley told me that the case was to be filed in the name of Holmes, and then still later I was instructed to write it up in the names of Holmes, Manley and Behimer.

2785 DX 757 is a letter that I wrote to Mr. Holmes, dated January 22, 1918, in reference to this process that we are talking about here and in part reads:

2787 "The two applications on the above process are being prepared in accordance with your recent telegram to Mr. Manley, and they will be finished within the next few days.

"I imagine that Mr. Behimer may be somewhat disappoin'ed in not having his name connected with the application on the coil arrangement, as he has a number of times spoken to me of this apparatus as if it embodied special ideas of his own; and in fact, relying on my conversation with you in Houston recently and thinking to gain more cooperation from Mr. Behimer in drawing up the application, I told him that it was my understanding that in case a patent was applied for, it would be taken out in your name

and his. You may also recall that Mr. Behimer seemed to think that our original applications on the Vertical Still embodied some of his ideas. I am merely mentioning these facts for your information.

2789 1479 "The more I study the coil arrangement the more I am convinced of its value from a patent standpoint in view of the present gasoline situation. It represents to my mind a distinct difference over anything patented of which I know. For this reason it seems to me that if you have the original letters of instructions, drawings, or other similar matter, showing that you conceived this arrangement, it should I think by all means be taken out in your name."

2792 DX 756 which is my letter on February 2, 1918 to Mr. Holmes reads in part as follows:

"I inclose copy of the specifications which I have prepared on the coil and drum arrangement, and would be glad to receive any criticisms or suggestions that you wish to make in regard to same.

"As I had anticipated, Mr. Behimer was plainly disappointed in not having his name connected with this application. He claims that the use of the drum in connection with the coil was suggested, as well as

2793 developed by himself, and that it is this feature which makes the system a patentable one."

DX 765 is my letter of February 19, 1918 by which I transmitted to Mr. Manley the retyped application of which DX 694 was the working copy.

2794 Just before I went into the army in April 1918, Mr. Mackenzie was down in Texas on a trip from New York, and I discussed the matter of filing the patent application on this coil and drum process with him.

The blue print, a photostatic copy of which has been introduced in evidence as DX 667 is what we have always called the original drawing on this coil and drum process. I made a search in an effort to obtain the original drawing from which this blue

2795 print was made. We called on the engineering department to make a search and, as I recall, we were

2795 1480 not satisfied with their search but some of us went through and ransacked the place over there, went through every drawer, and we did a lot of searching in trying to locate it.

I went over to the vault and searched through all

of the drawers, up on the top, everywhere I could think of, thinking it might have got stuck away in some cranny somewhere, but I was unable to locate the original drawing.

2796 This particular print, DX 667, was Behimer's print;
2797 he had it in his files and after I got this print from Mr. Behimer's files, it was sent up to New York, to Mr. R. J. Dearborn, the patent attorney of The Texas Company. It was kept in the corporate files in New York after it was sent to Mr. Dearborn.

1481 *Cross-Examination by Mr. Blenko.*

2800 I do not know how many blueprints were made of the drawing which corresponds to DX 667. I do not
2801 recall ever having seen any other than the one which forms the exhibit.

In the ordinary course of business, any print which was made went into some department. The only reason that I suppose the tracing was destroyed was my inability to find the original.

2803 I started working on the first draft of the Behimer specification in December 1917 and I think the last draft was sent out on February 19, 1918. I was still discussing it with Mr. MacKenzie as late as April 1918, but I don't recall that I advised him any further. I believed that all my work on this specification was
2804 completed in February 1918.

On February 19, 1918 following Mr. Manley's instructions I sent him a copy of this case, and also a lot of information in regard to cracking. In April 1918 I had a discussion with Mr. MacKenzie at Port Arthur and another at Houston. I believe it was around the 23rd or 24th of April. At this time the
2805 specification was still in the same form that I had put it in the month of February and nothing had happened in the interim.

At the time I came with the company Mr. MacKenzie was the most active individual in the company on patent matters. He was charged with expediting these cases during the time I was in the army and prior to the time that I was succeeded to the job.

2806 1482 Mr. MacKenzie is still with The Texas Company and is assistant to the vice-president. I never

received a copy and I am quite certain I never saw the letter dated January 30, 1918. (DX 761)

I had some discussion with Mr. Manley regarding the matter of filing applications during the months of March and April of 1918, that is, I had some discussion with Mr. Manley sometime before I left for the army.

I enlisted in the army in December 1917 but was not called to active service until April 1918. Until April
2808 1918 I remained in the employment of The Texas Company. I then entered the army and came back to The Texas Company in December of 1918.

It was sometime in the fall or winter of 1916 that I discussed the jet pump with Mr. Behimer. At that
2809 time Mr. Behimer's discussion of a jet pump was something that he was still planning to use in the future.

I do not know now who is in charge of the engineering department at Port Arthur but in 1916 I believe Mr. Dan Moran was in charge. Mr. Higgins was head draftsman at that time, and the drawings or blueprints would be in his custody.

2810 1483 There have been so many different investigations of the search for the original of the drawing of DX 667 or for any blueprint record that I am unable to say the last time I looked into this matter, but my best recollection is that it was some ten or twelve years ago.

I have been stationed in New York City for the past ten years.

1484 JAMES G. DETWILER, 32 East 36th Street, New York City, N. Y.

Direct Examination by Mr. Thiess.

2997 I am connected with the refining department of The Texas Company. I have been employed by The Texas Company since 1911, with the exception of time out in the army, about eighteen months during the last war.

2998 Mr. Donaldson went to the same camp I did but he didn't stay there until the camp was over. The camp was from some time in August until November, 1917. I believe Donaldson left in October.

I have a degree of Bachelor of Science in chemistry from the Pennsylvania State College in 1910.

I came to the Port Arthur Refinery of The Texas Company in the early part of August, 1916. I was there until some time in August the following year.
2999 I was transferred to Port Arthur to take over the new research laboratory that had been built there during the period that I had been at Bayonne the three years previous.

My duties in connection with this laboratory at Port Arthur were to supervise the various research experiments that Mr. Holmes and other had outlined and to periodically make reports to either Mr. Holmes, Dr. Gray or Mr. Manley, and first of all, of course, to equip the laboratory; to install a library and all other equipment necessary for conducting the work, and also to engage personnel.

2999 1485 Mr. Behimer was employed there at the time I took charge of the laboratory. Mr. Behimer was later transferred to this laboratory of mine and
3000 he reported to me I believe about the third week in August, although I had met him prior to that time.

The procedure employed in making and keeping records of experiments at Port Arthur by the company in the laboratory was as follows:

When a new experiment along any lines was started it was first given a number by the Houston office. Then there was an outline made including the purpose of the experiment, the nature of the equipment to be used, the number of men, perhaps, to be employed, depending upon the nature of the work, and a full outline of the type of data which would be developed or which it was hoped would be developed. A permanent record was kept of all these data and other pertinent information that was developed in connection with the conduct of the experiment.

3001 The contact between the laboratory and the engineering department was ordinarily through Mr. Burlingham, who was one of the men I had employed and who was a machinist. He usually made the preliminary sketches and took up the question with the engineering department of having the equipment built.

In the case of larger sized apparatus, however, permission was granted for the man in charge of the

experiment to deal directly with the engineering department, and we had also certain regulations concerning spending money. That is, we could spend up to a certain amount, and more than that had to
3001 1486 be obtained through special grant by Mr. Manley or others.

The sheets for experimental data were prepared by
3002 the man in charge of the experiment. The entries were usually made by the operators in the log sheets.

The policy of the company with respect to these cracking experiments was very strict secrecy.

3003 DX 769 is a memorandum dated Port Arthur Works, November 29, 1916, which I wrote, reading as follows:

"The results of Experimental work being done under the jurisdiction of the Research Laboratory are to be reported to three men only, namely Mr. R. C. Holmes, Dr. G. W. Gray and Mr. F. T. Manley. Such reports to be issued from this office.

"Engineers, mechanics, boiler-makers, carpenters, brick-layers and other refinery employees at work on the construction of various apparatus in connection with the work of the Laboratory, are to be given only such information as may be necessary to enable them to do their work properly.

"Any infringement of this rule will be sufficient cause for dismissal from this department. This letter has not been issued because of any report of 'leaks,' but merely in accordance with instructions received in regard to the conduct of the work."

3002 I had practically daily contact with Mr. Behimer while I was there. His office was right close to mine in the new building, and I also had a private laboratory for him fixed up on the lower floor of the building.

3004 I came down with Mr. R. C. Holmes to Port Arthur about the 4th or 5th of August, 1916 and I met Mr. Behimer either that day or the following day. I had numerous conversations with him relative to the work he was doing on cracking.

3005 1487 The first long conversation, as I recall it, was on the day when he was transferred over to the research laboratory about the second or third week in August.

We discussed all the different types of cracking

processes that we had done work on, those which we had worked on at Bayonne and those which Behimer investigated, and we also discussed the work which he had done with the Cross laboratory in Kansas City, and he asked me something about what work had been done up at Bayonne.

3006 Some time between late summer and early fall, 1916, we had a long discussion on what would be the final answer to this cracking problem.

Behimer told me that he thought that no process would stand any chance of permanent success unless it was made continuous, and he also outlined his ideas as to how such a continuous process would work, and he based this propsed scheme on observations he made in the bomb experiments, the Dewar-Redwood apparatus, and his work on the continuous coil, which I believe was in operation at that time although I never had really had anything to do with that. He stated that he had discussed this with others before; I am not sure who, but I believe someone in the engineering department, and his idea would be to have a heating coil, which was connected with a drum or still, and

3007 have means for continuously pumping the oil through this coil and drum, vaporizing from the drum through a certain type of backtrap or air condenser, which would condense out what he called the heavy kerosene or the kerosene cut which was causing trouble, I believe, in other experiments, to continuously

3007 1488 pump this back with a stream of fresh charge going to the heating coil, at the same time continuously drawing off the residue from this tank; and he believed that by that means he would be able to overcome what had been the biggest difficulty in all his previous work, the deposition of carbon in these coils, that is that the carbon would more than likely be carried along by the stream of oil into this large drum at the back and could be drawn off there with the residue.

That in substance was what he told me at that time, and he said that one difficulty with the scheme would be the return of this reflux of the heavier condensate back into the charge, and that he thought that that

3008 might be overcome by an idea presented to him by one of the engineers, and he said they were going

to try this ejector or jet pump arrangement or planned to.

I immediately told Mr. Manley on his next visit to Port Arthur and he also discussed it with Behimer, and he said to arrange to have the equipment built.

3009 Behimer or Burlingham showed me a drawing of the equipment later.

DX 669 is a drawing of the apparatus. It appears to be the same as the one I saw at that time. I haven't any definite recollection of when I first saw a blueprint of this drawing. It may have been in January or February, 1917. I know that we made arrangements to have the appartus built. Equipment was ordered, such new equipment as was necessary.

DX 670 is a letter dated March 23, 1917, signed
3010 by me and addressed to Mr. F. T. Manley, which reads as follows:

3010 1489 "The enclosed list of tanks are needed by Mr. Behimer for experiment 8.

3011 "The experiment is the one making use of the tubular apparatus under high pressure. The material on this list is of some magnitude and I thought it best to submit for your approval before ordering the same from the boiler shop."

I do not know where that list referred to in the letter is.

I can't tell what the tankage which is referred to in that letter was. It may have been the storage tankage for either distillate or charge, or it may have been part of the apparatus itself. But this tankage was to be used in connection with the apparatus for
3012 cracking according to the disclosure that Mr. Behimer made.

This apparatus was built. It compared quite closely with the drawing, DX 669. There were some changes. The drawing does not show that the drum was heavily insulated. The drum in the rear was insulated. Also
3013 this line from the backtrap No. 2 was insulated down to the jet pump, which was not insulated. There were changes made in the furnace. There were four tubes in the bottom row and only two in the top; that was done, as Mr. Behimer told me at that time, for getting better control of the temperature in the tubes. The baffles are indicated as vertical whereas actually they were placed in there horizontally. I think there was

also a charging line that was only three-quarter inch and it is shown here as three-inch. There was also an arrangement to draw off samples from both the drum at the rear of the furnace and also from the backtrap line going to the jet pump.

3014 1490 I saw this apparatus in operation. I was there during the first three runs at least. I am not sure whether I was there during the fourth. That was during May and June, 1917.

3015 I followed the operation fairly closely. I was not there all the time, but I was down there at some period of the run, either day or night, whenever it was running.

I remember distinctly following the temperature ranges which he was able to get, the pressure ranges, and noted that he never was able to obtain the pressure which Mr. Behimer had requested that the ap-

3016 paratus be built for. I asked him if this jet pump, which had caused quite a lot of discussion, was working properly, and he said it was and asked me to feel the thing to show that the oil that was going through there was hot. On the opposite side of the pump where the charge came in it was cool. The oil was about 80 at that time of the year, perhaps a little hotter, atmospheric temperature. The other side was very hot. Of course the pump itself was very, very hot. I actually felt this pump and the line, the backtrap line, when Mr. Behimer asked me to. I found that it was hot.

3017 DX 759 is a report to Mr. F. T. Manley, with a copy to Mr. R. C. Holmes, on the results of the first three runs on the experiment No. 8.

I actually dictated the report from data which were furnished me, in most cases by Mr. Behimer. That

3018 report covered most of the pertinent data obtained during the run, such items as temperature, pressure, time, material going through, and the nature of the products obtained. There is also data with respect to yields on page 2 of the report. In connection with that report there are several errors contained in

3021 that report, typographical errors. I can identify DX 683. I received this letter about June 28th, 1917.

1491 The letter DX 684 was received by me. I am not sure that I was at Port Arthur at the time when it arrived but I know that I saw the letter after-

3022 wards. I know I was away on vacation some time around that period but Mr. Behimer, I believe, reported those last runs himself.

Testimony under the rule:

"Q. What if anything did the experimental data which you saw with respect to this operation of experiment 8 and your observations of the runs indicate to you as to the process and apparatus? What did it demonstrate to you?

• • • • •

"The Witness: Well, I considered that Behimer's reasoning was justified and that the process showed considerable promise, and while we didn't have the equipment that he wanted, yet with this equipment as built he did secure results which looked decidedly promising."

(End of testimony under the rule.)

1492 *Cross-Examination by Mr. Thomas.*

3031 Mr. Behimer first disclosed his idea to me in the late summer or early fall of 1916. At that time the coil and drum disclosure was in the embryo stage. I so characterized these experiments when testifying in the Texas v. Anderson-Prichard case.

3032 PX 7* is a report summarizing runs 6, 7 and 8. I did not make any corrections on those summaries. The corrections I made were on the actual pressure, temperature and log sheets which are attached to a copy of the report marked DX 759.

In 1917 I was in charge of all the research laboratory work of The Texas Company at Port Arthur. I had general supervision of all the research work
3033 until August 1917, when I left the employ of The Texas Company and entered the army. In 1917 there were probably ten or twelve research problems going
3034 on at the same time. I followed them all as closely as I could, but of course I could not follow every detail. I believe I was fairly thorough in my observations.

Referring to experiment 8, I never saw a complete run, from start to finish, made on that experimental

* This exhibit offered in Behimer's testimony (R. 1160) in "unclean hands" issue.

3035 device. I may have seen some parts of runs 6, 7 and 8. I was not there at the time some of the runs were made. The only ones that I have any recollection of are runs 6, 7 and 8.

I never saw the interior of the partial condenser in experiment 8. I saw the interior of the furnace tubes when they were cleaned out. I don't recall
3036 1493 on which run I saw the tubes during the cleaning. I recall having seen the tubes during a clean-out because Mr. Behimer asked me to come out and look at them. I never prepared any memorandum as of the time I witnessed runs 6, 7 or 8, or parts of those runs.

I am testifying here entirely from my recollection and study of the records, and the records were all
3037 made by someone else, that is, the operating conditions and the results were all records made by some-
3038 one else. Aside from those records, my entire testimony is from memory.

PX 7 was prepared from reports and data furnished to me by Mr. Behimer, and it was not prepared from information or knowledge that I had obtained from observing the results from each run.

I observed some distillations made to determine the yields and character of products produced in the experimental operations of experiment 8.

I testified as follows on page 325 of the Texas v.
3039 Anderson-Prichard record:

"Q. Did you ever see this distilling process in operation at the time around when you were there at Port Arthur?

"A. Yes, sir, I have seen it in operation in Mr. Behimer's private laboratory.

"Q. Do you remember about when that was?

"A. Well, as I recall, this apparatus was designed before the coil and drum experiment was built and had been used in previous experimental work.

"Q. Did you see it used on any of the products from this coil and drum experiment No. 8?

3040 1494 "A. I do not recall any, no, sir."

and I believe that testimony is true.

I do not know from my own observations what part of the vapors passing from the drum to the air condenser were condensed therein and returned to the coil as reflux condensate.

1495 *Redirect Examination by Mr. Thiess.*

3041 Q. Did you see any samples of back trap drawn from the reflux leg during the operation of this No. 8?

A. I saw the test run samples which were shown me by Mr. Behimer. I did not actually see them drawn.

Q. But did you see the material that was withdrawn from the—

A. Yes.

Mr. Thomas: Now if your Honor please, I object to that as hearsay.

The Court: Q. To get that straightened out, did
3042 you see this stock drawn, or the samples drawn, see it being drawn from the still?

A. I do not recall that, your Honor. I remember seeing the samples which Behimer showed me in particular to indicate the difference in color between that and the samples at the end of the line.

The Court: This evidence would not be admissible.

In the operation of one of these experiments the operators draw the samples and record the records
3043 on the log sheets. An operation of this kind runs for various periods. Under those circumstances it would not be possible for the man in charge to be present during the entire period if the run was fifty or sixty or seventy hours in length. The man in charge of the experiment, and I, occasionally, checked when we went around to see the progress of the experiment, as to whether or not the work was being properly done.

3522 1496 A. S. BAILEY, Houston, Texas:

Direct Examination by Mr. Thiess.

3523 I am vice-president and assistant manager of the Texas Pipe Line Company. I was associated with The Texas Company, between the years 1908 and 1925. In 1917 I was chief engineer of the Port Arthur Works Refinery. I arrived at Port Arthur to take that position in February or March of 1917. As chief engineer at the Port Arthur Works I had gen-

3524 eral supervision of construction and maintenance of the plant.

In my duties I had certain work to do in connection with the research laboratory.

I know Mr. Otto Behimer. I first met him just subsequent to the time that I went to Port Arthur Works in 1917. At that time Behimer was conducting experiments and doing the research work in connection with the cracking ideas that The Texas Company at that time were trying to develop. Mr. Behimer consulted me with respect to this work that he was
3525 doing and on experiment No. 8 as to matters pertaining to the design and construction of the equipment that was installed for it. He consulted me more particularly on the construction and installation of a drum that was necessary in this experiment together with a heating coil, a so-called jet pump, and the condensing and cooling equipment. The return bends in the heater were quite a problem to solve. The refinery equipment then operated at or very near atmospheric pressure whereas Behimer's equip-
3526 1497 ment was designed to operate at greatly elevated temperatures and pressures.

We were ultimately successful in getting the plant constructed and in operation. We had considerable difficulty in maintaining the equipment in condition to operate at those high pressures due to leakage and other mechanical reasons. In the oper-
3527 ation of this apparatus it got on fire several times because of the pressure conditions that we were trying to obtain. This apparatus was completed in May or June of 1917.

I saw this apparatus after it was constructed. It consisted essentially of a coil laid horizontally in a brick setting. From this coil a line was connected to near the bottom of the still which was set in a vertical position in a brick setting. From this still a vapor line carried the vapor to a so-called air condenser. From the top of the air condenser a line took the uncondensed vapors into a condensing and cooling coil where whatever product was produced was
3528 condensed to a liquid. From the bottom of the air condenser a line was carried back to a connection with the charging line, into a jet pump, the discharge from

which was carried to the inlet end of the heating coil. From the bottom of the so-called still or drum a line was installed to afford a means to draw off the heavy tar or residium from the cracking operation.

DX 669 is a drawing of the apparatus. I have no particular recollection of when I first saw this drawing. It happened during that time, those early days at Port Arthur.

DX 669 essentially is what was constructed. I saw
3529 this apparatus under fire and under operating conditions.

3529 1498 DX 686 is the general drawing of a similar apparatus that was designed in the office at that time. The only difference, essentially, is that it is larger than the one that was constructed and then in operation. That design was made in response to a request on the engineering department that we pro-
3530 duce designs for a larger apparatus for Behimer.

Those pencil notations on this drawing are in my handwriting. These were evidently put on the drawing during some conference with Behimer respecting the design of this particular piece of apparatus. I notice here evidently we had decided to drop the air condenser somewhat. There is a figure indicating that it should be set at 10 feet maximum above the top of the heating coil. I couldn't say exactly why that was done.

3531 The vapor lines shown in ink on the drawing are of poor construction in that the flange is connected to that head. Mechanically the better location is on the side of the drum, which is shown by this ring pencil mark.

At the bottom the tar drawoff line is shown penciled as being enclosed in a brick housing rather than extending up to a point above the horizontal center line of the still.

3532 The word "backtrap" is written over a line that is drawn to a connection with the jet jump. There is also shown here a characteristic trap before the connection is made to the jet pump. In other words, you would have a loop in that line.

All these pencil notations on this drawing are in my handwriting and were put on there very shortly after the date of the drawing. Another drawing was

made incorporating these changes in pencil, be-
3533 1499 cause the changes were so extensive here this drawing couldn't serve any useful purpose after the changes were made. This apparatus was never built.

Our engineering department had been reduced by 50 or 60 per cent of its usual strength due to the enlistment in the army of our men. War had been declared at that time. The government had clapped on a series of priority orders. No materials could be bought unless our application for priority in the purchase of materials was approved by a central body. What we were trying to do was rather a new thing to us. We were not able to enlist the aid of any outside people. If we had been, we couldn't have got
3534 the materials, only after considerable delay, and for that reason I am sure the thing was never built. Notwithstanding the fact that we couldn't get the material, we made another drawing. I couldn't recite the drawing number.

3535 We went to some length to try to procure equipment that we thought was reasonably well designed to do that work. It was impossible for us at that time to get a pump which would take the place of the so-called jet. That was one of our major ideas, was to substitute a mechanically operated pump for that jet pump. Return bends for connecting the individual tubes in the heater presented a problem both with respect to their construction and the method of joining them to the preheater tubes so that a tight safe
3536 joint could be made. We had considerable discussion with respect to the drum that was necessary, trying to find a manufacturer who would guarantee a drum to operate under the conditions that were imposed upon it.

3536 1500 DX 794 is a letter written September 21, 1917, by R. C. Kinzer who was at that time chief draftsman in the office of which I had charge, to R. G. Dawson, who was our purchasing agent located at Houston. That letter was written in connection with our request for information on this particular drum.

3537 DX 795 is a letter under date of September 24, 1917, from Mr. Dawson to me. Mr. Dawson refers in this letter to my letter of the 21st, DX 794 and replying, he stated that so far as he knew there were no manu-

facturers prepared to quote on this special equipment without drawings and specifications.

3539 DX 796A is a letter under date of October 6, 1917, to Mr. R. C. Dawson enclosing a drawing DX 796B and giving specifications.

Another letter, DX 687, under date of November 5, 1917, from Mr. Dawson to me, is in response to 3540 the letter (DX 796A). Mr. Dawson in his communication (DX 687) transmitted a quotation received from the Kellogg Company respecting the construction of 3541 the still that was requested in that letter (DX 796A). On this quotation attached to DX 687, in my handwriting, is a note to Behimer for him to note it and to return it with his thoughts.

3543 DX 688, is a letter by Otto Behimer to myself. Behimer suggests that Mr. Manley, who was the then manager of the refinery operations at Houston, has indicated that he wished to go ahead with the construction of the coil experiment, DX 686, and that therefore we should draw up final specifications for the drum. Among other things Mr. Behimer mentions the 2″ coil and connections and some of the difficulties there.

3544 1501 DX 689 is a letter from myself to Behimer, dated November 8th; it refers to the proposal and design submitted by Kellogg for that drum of DX 686 and I stated that I believed we were warranted in going ahead with "the rest of the design for this apparatus."

DX 690 is a letter from Mr. Manley to myself indicating his feeling that before we can go ahead with that construction some more consideration will have to be given to it and that had to have "complete information in the way of estimate and requisitions to cover the material required." That refers to that apparatus designed or indicated on that drawing, DX 686.

3545 DX 691 is a letter to Mr. Dawson indicating our need for certain return bends for the apparatus of DX 686.

DX 692 is a letter written by F. P. Risdon, who was 3546 the then assistant chief engineer in the refinery department located at Houston, to myself, in which he refers to DX 691. He goes on at considerable length here and refers particularly to return bends for the

apparatus of DX 686. The handwriting at the top of the letter is mine. It reads "R C K" under "Behimer" and "Burlingham," "Please note and return," is in my handwriting.

3549 I did not get estimates for all the material that was to go into this equipment. The letter DX 690 pertains to the estimate on this equipment. We did not
3550 get these estimates for that equipment that Mr. Manley refers to in DX 690. Nothing was done toward procuring further estimates to build this equip-
3552 1502 ment. I have no personal knowledge of attempts to get further estimates, only the letters that I have with respect to those matters that are there.
3554 It was, of course, discussed personally by myself with Behimer, and as the chief engineer I gave instructions in what manner to follow up the general idea of getting materials, estimates and everything else completed.

3555 As chief engineer the construction of the commercial stills for cracking at Port Arthur came under my general supervision. The work was started the late spring or early summer of 1919. Preparation was made first for ten batteries but ultimately was increased to fourteen and later to twenty-four. These batteries were put into operation at various times starting in January, 1920. Those batteries cost in the neighborhood of $200,000 per unit.

3556 DX 797 is a blueprint from a drawing which shows the plan and the arrangement of a typical battery of pressure stills as then designed and constructed. The economizer and preheater are indicated on the drawing. The left upper portion of the drawing shows the disposition of the four stills and their brick setting, to the right of which is shown the coils of the condenser box, again to the right of which is shown the location or general arrangement of the control house.

3557 DX 798 is a blueprint from a drawing showing in section the brick setting of the stills, the stills themselves, in side elevation, the air condensers, with the piping in section and side elevation, together with the cooling coil.

DX 799 illustrates the longitudinal and cross-section
3558 of the so-called preheater. These drawings that
3558 1503 I have just identified all relate to the commercial cracking apparatus.

After the erection of these twenty-four batteries, we installed on battery 14 a so-called surge pump to
3559 inject the backtrap produced in the air condenser back into the inlet end of the heating coil in the preheater. That change was made about a year later, in 1921. After tests showed its efficiency on battery 14 all of the batteries were so equipped.

DX 800 is a drawing approved by me on May 27th,
3560 1921, showing shop details of piping for the installation of surge pumps. This pipe equipment was used for injecting the backtrap into the inlet side of the preheater coil. DX 730 is a drawing of additional piping details for the surge pump installation. DX 731 shows a general piping scheme of the way the surge pump was hooked up.

3561 Besides the first twenty-four batteries, finally appropriation was made for constructing additional ones up to battery 72. Those batteries were constructed with the surge pump. The surge pumps that were used on these batteries were Worthington pumps secured from A. M. Lockett & Company, New Orleans, at a cost, set up complete, of $10,000.

After the original commercial batteries had been de-
3562 signed and built and operated at The Texas Company plant at Port Arthur without the surge pump, I tried to enlist the services of the Worthington Pump & Engine Company to produce a pump for us along the lines that I outlined.

3563 One man with whom I had many conferences was F. D. Rahm, who was then manager of the Houston office of the A. M. Lockett & Company of New Or-
leans, who were the Worthington agents in the
3563 1504 south part of the United States. I had these conferences with this man over many months, during this time, 1920, 1921, 1922.

3564 I also conferred with our own engineers in Houston, F. P. Risdon and B. E. Hull and others. We were all looking for an answer to the same problem. Our discussions then had to do with the duties of the pump, how we thought it should be designed for safety, who we thought we could get it from, and questions such as that.

1505 *Cross-Examination by Mr. Blenko.*

3564 The Texas Pipe Line Company is a subsidiary of The Texas Company. When I consulted with Mr. Behimer about the apparatus for Experiment 8, the apparatus was partially in existence, but I could not say just what state the construction was in.
3565 My best recollection is that the site had been prepared and the foundations were being built. I could not say as to whether the furnace, coil or drum were in place.
3566 I met Mr. Behimer in February or March of 1917. At this time the construction for this particular unit had been approved and the construction work was going forward. The conferences that I had with Mr. Behimer had to do with the current work. I knew in a general way that prior to the coil and drum experiment designated as Experiment 8, there was in existence a coil not embodying a drum, that was also designated as Experiment 8, but I have no personal knowledge.
3567 I do not know that that coil was employed in the coil and drum experiment designated as Experiment 8. I do know the coil I was familiar with had return bends. All my testimony on direct was on return bends for some future installation and not for Experiment 8. The drum was constructed according to the design previously made.
3568 When I first went to Port Arthur my first duty was to familiarize myself with everything that was going on in the plant. Aside from this particular construction, we had a very large construction program going on, and it took me some time to
1506 orient myself, and during that time was when I tried to dig into Behimer's work and find out what it was all about.
3569 The top portion of the drum for Experiment 8 was insulated. I cannot be sure that it was insulated at the time the first runs were made. Insulation for those temperatures was quite a problem.

The return bends stuck out beyond the brick setting of the furnace. We did not employ the well-known ammonia bends that were then commonly employed
3570 in the industry. We never tested the ammonia

return bends. As I recall that was a 2 bolt bend and not my idea of safe construction. Some adaptation of the ammonia bends were used subsequently.

I cannot say definitely whether the vapor line or back trap was insulated in the coil and drum experiment. The jet pump was insulated. The raw oil
3571 line was not insulated. My whole recollection of that apparatus as to the specific details is rather vague. As to generalities, I know something of it.

I testified in The Texas Co. *vs.* Anderson-Prichard case on page 887, as follows:

"Q. I show you Plaintiff's Exhibit 64 and ask you what if anything you had to do with the preparation of that drawing?

"A. On the drawing I previously had I made some notes on Y-2200. This drawing is supposed to be an interpretation and rendition of the final equipment as they would get it out, from the notes I put on the other drawing myself."

3572 DX 693 carries out the essential changes that
1507 were shown in my own handwriting on drawing Y-2200, DX 686. As of the date of DX 693, I had completed the design for the pilot plant which was to follow after Experiment 8. Subsequent to
3573 Experiment 8 there was some other work done. I remember there was an experiment known as Experiment 11-B. I recall Experiment 12. I cannot tie up the number of experiments with the construction.

DX 796-B refers to the high pressure still experiment No. 12, dated September 5th, 1917. DX 796
3574 on its face refers to experiment 12. DX 795 likewise refers to experiment 12. DX 794 and DX 795 are dated in the same month. I have no recollection exactly what experiment 12 was. Apparently DX 794, 795 and 796 relate to the same experiment. DX 687 relates to the same drum as is shown in
3575 DX 796-B. Referring to DX 688, 689, 690, 691 and 692, I cannot define in my own mind what is meant by experiment 12. Experiment 12 was probably the so-called pilot plant. The correspondence which I identified in my direct examination related to the plant as outlined on the drawing on which my notation is shown. If all of these matters are tied up
3576 to the one project, Mr. Manley's letter on November

10th indicates equipment that we have shown on the drawing Y-2200; DX 686. That is my recollection.

I procured materials for experiments other than this modified pilot plant during the war years. I have no recollection of writing any letter wherein I reported inability to get materials for the pilot plant on account of priority orders or for any other reason.

3577 1508 The scrapers that I referred to relate to DX 798 and were for the purpose of scraping carbon off the sides of the vertical stills in the battery. The carbon was a serious problem and it had to be removed. These scrapers were designed after much experimental work had been done. They were always more or less of a nuisance.

3578 In that set-up the back trap was returned to one of the vertical stills. There never was a commercial setup wherein the back trap was returned to the coil until late in the year 1921.

The surge pumps employed were made up by The Texas Company using the Worthington pump as a basis, but other parts, specifically the surge lines and valves at the end of the surge lines, were fabricated by The Texas Company. I do not recall exactly
3579 how the surge lines were. DX 731 shows the surge line arranged with a double gooseneck connecting the pump and the valves, and the line in between was supplied with a charge line so that the cold oil could be put in there. The reflux was too hot and the
3580 reciprocating part of the pump would not handle that oil at that temperature and at that pressure. The packing around the rods would not hold, so we removed the block and valves from the pump and then the reciprocating portion of the pump itself operated at lower temperatures. It was to keep the pump cool that raw oil rather than reflux was introduced into the surge lines.

3580 1509 *Redirect Examination by Mr. Thiess.*

The drum shown on DX 796-B is the same size as the drum that is shown on this drawing Y-2200 (DX 686). One is marked 4 feet by 20 feet, and the

other is 4 feet by 20 feet. They are both equipped with a manhead. DX 686 is not equipped with a
3581 manhead except in pencil as I have shown. DX 796-B shows that manway.

DX 693 is not a finished drawing. It is a preliminary drawing to get proportions and general lay-
3582 out. Our practice was to put finished drawings on tracing linen, not on paper. On this drum of DX 693 are two draw-offs, one from the bottom and the other which is shown in dotted lines. It was not our intention to have two draw-offs on that drum on the
3583 ultimate drawing.

On this drawing DX 693, no jet pump is shown. I am sure that is an error. I might mention, the man who made that drawing named M. C. Hartzler, was a young boy just out of college and had had no prior experience with this sort of work.

1510 *Recross Examination by Mr. Blenko.*

3584 Referring to DX 686, the pencilled notations in my handwriting show that the manhead was to be placed in the top of the drum. The drawing shows at the top an extension or neck with a flange that is marked "manhead." Also on the side of the drum there appears the notation "16-inch manhead" and that particular one is shown as an inserted plate without a neck or a flange. DX 693, the amended drawing, shows that manhead only at the top, whereas DX 796-B, to which the correspondence relates, shows a manhead at the side and none at the top.
3585 On DX 686 the scale is stated to be ¾ inch to the foot, and that is likewise the scale of DX 796-B, therefore the two drawings are to the same scale. If I laid drawing 796-B over Exhibit 686 so that the two drums could coincide, that results in interference between the manhead and the setting, that is, the manhead of 796-B and the setting for the drum in DX 686.

UNITED STATES CIRCUIT COURT OF APPEALS

For the Seventh Circuit.

I, Kenneth J. Carrick, Clerk of the United States Circuit Court of Appeals for the Seventh Circuit, do hereby certify that the foregoing printed pages contain a true copy of Volume 2 of the printed record, printed under my supervision, which, together with Volume 1, and Volume 3 to 7, inclusive, constitutes the record upon which the following entitled cause was heard and determined:

Cause No. 7912.

Universal Oil Products Company,
Plaintiff-Appellant,

vs.

Globe Oil & Refining Company,
Defendant-Appellee,

as the same remains upon the files and records of the United States Circuit Court of Appeals for the Seventh Circuit.

In Testimony Whereof I hereunto subscribe my name and affix the seal of said United States Circuit Court of Appeals for the Seventh Circuit, at the City of Chicago, this 18th day of August, A. D. 1943.

Kenneth J. Carrick,
(Seal) *Clerk of the United States Circuit Court of Appeals for the Seventh Circuit.*